Rapid Refresh status

Extracted from 30 Oct 07 RUC/RR Technical Review

NOAA/ESRL/GSD/AMB

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Development, testing, results on

- **Rapid Refresh cycling**
- **RR-WRF model configuration**
- **GSI for Rapid Refresh**
- **HRRR**

Plans

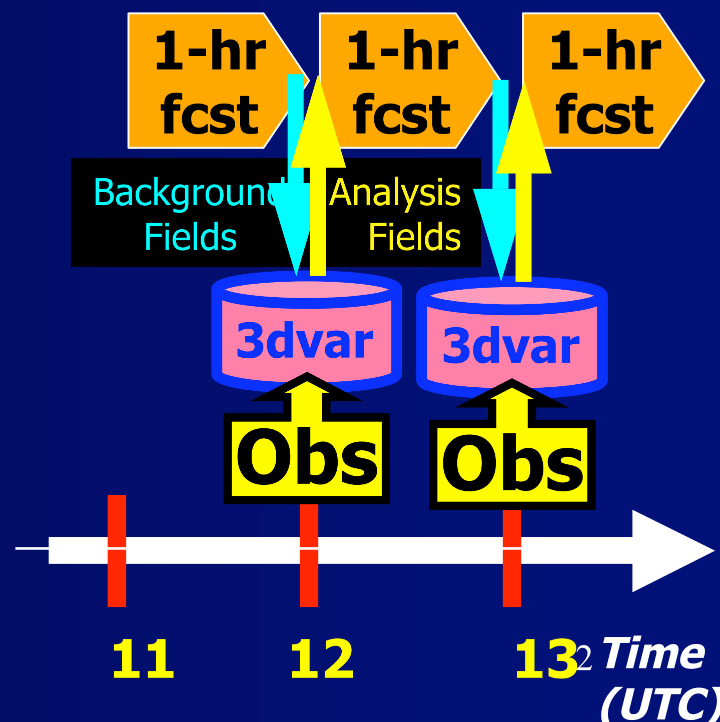
http://rapidrefresh.noaa.gov

Earth System Research Laboratory
SCIENCE, SERVICE & STEWARDSHIP

Rapid Refresh (RR) Purpose (same as for RUC)

"Situational Awareness Model"

- Provide high-frequency mesoscale analyses and short-range (1-12h) numerical forecasts for users including:
  - aviation
  - severe weather forecasting
  - general public forecasting



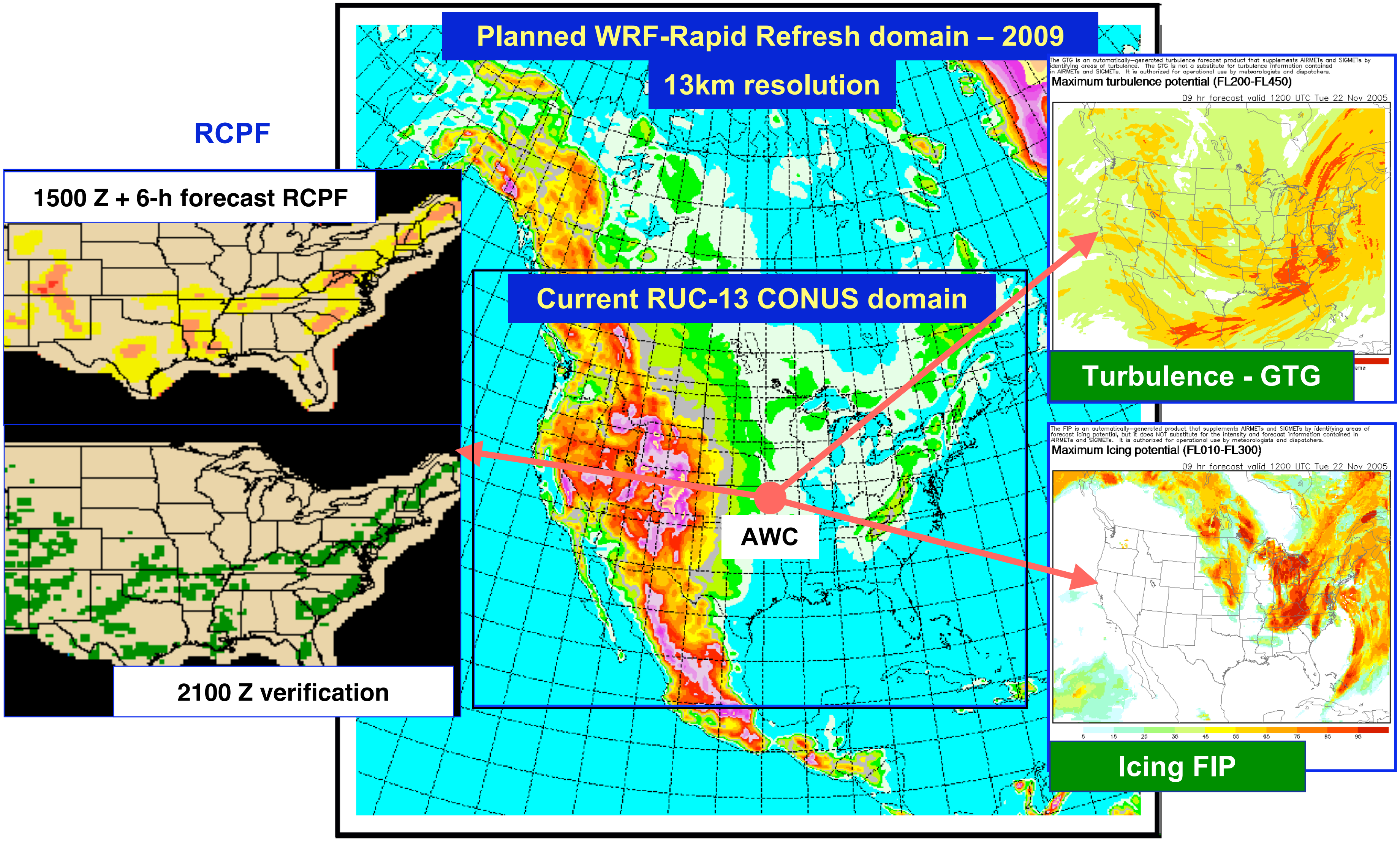
Expected users for Rapid Refresh

- NCEP Aviation Weather Center - airmets, sigmets
- NCEP Storm Prediction Center - severe weather watches
- Federal Aviation Administration (FAA) – CWSUs, WARP, air traffic management, free-flight (URET), ITWS..
- Airline flight dispatchers
- NWS Forecast Offices, NWS RTMA
- NASA Space Flight Centers
- NWS Operational Hydro Remote Sensing Center – US snow cover
- NSSL QPE project - snow level
- Initialization for WRF (e.g., WSI 5km RPM for television customers)
- Private vendors – forecasting (WSI, Weather Channel, …)
- Initialization for WRF-chem, dispersion models …

- Other Aviation Weather Research teams – icing, turbulence, ADDS/RTVS, convective weather, winter weather
- Private users through web sites, especially pilots (general aviation, soaring, balloons), sailors, windsurfers, etc.

RR - future backbone for high-frequency aviation products

Icing Potential (FIP), Graphical Turbulence Guidance (GTG), National Convective Weather Forecast (NCWF), and other aviation weather products



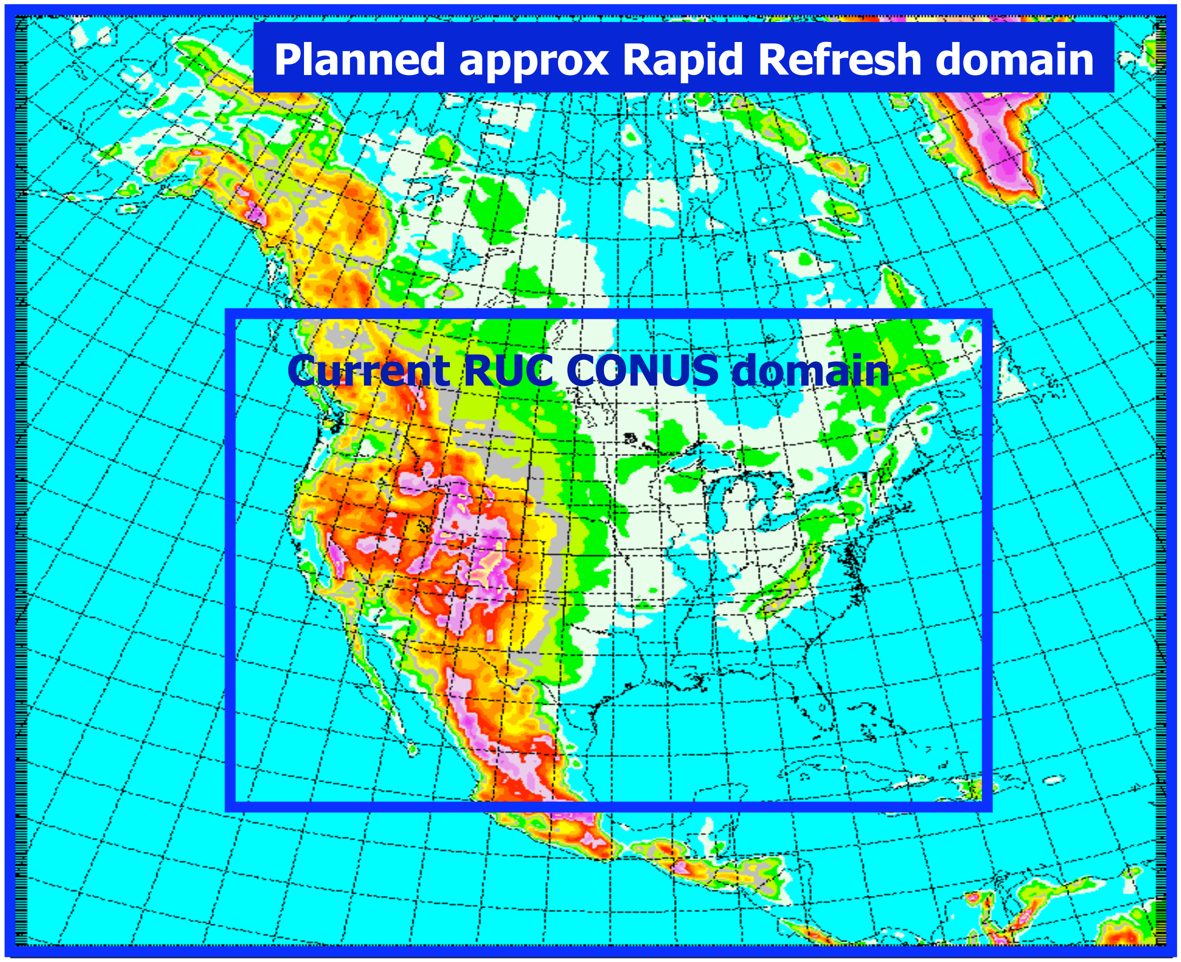
NOAA/ESRL/GSD, NCEP, NCAR, U. Okla, others

RUC

Rapid Refresh (2009)

NWP updated hourly w/ latest obs
- Aviation / transportation
- Severe weather
- Decision support tools

Hourly NWP Update for:
- CONUS
- AK/Can
- Pac/Atl
- Caribbean



RUC/Rapid Refresh Technical Review - OUTLINE

1:30 - 1:50	RUC upgrade - assim - radar reflectivity, mesonet/RTMA, physics -	Stan Benjamin
1:50 - 2:15	Observation assessment activities - TAMDAR aircraft obs w/ moisture, larger obs sensitivity experiment (OSE) -	Bill Moninger, Brian Jamison
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3:15 - 3:25	Future of Rapid Refresh	Stan Benjamin

RUC to Rapid Refresh

• CONUS domain (13km)	→	• North American domain (13km)
• RUC model	→	• WRF model (dynamic core in question until Sept 07)
• RUC 3DVAR	→	• GSI (Gridpoint Statistical Interpolation)

Some History of the Rapid Refresh

- 2003-2005 - WRF-RUC testing (WRF initialized with RUC initial conditions)

- 2006 - Controlled ARW, NMM core comparison
  - Result: Physics interoperability between cores
  - RUC init conditions (incl. clouds) - 13km CONUS domain
  - Controlled retrospective for all 4 seasons (help from DTC)
  - Recommended ARW by slight margin in Aug. 2006

RR-core-test comparison experiments ESRL/GSD and DTC (Dev. Testbed Center)

- GOAL: Recommendation from GSD to NCEP/EMC on preferred version of WRF core …

  Choices
  - ARW
  - NMM

•Focus on ~13km/50-60 levels, short-range (1-12h), aviation/severe-weather application

VIA

- *Fully controlled* core-test comparisons
  - Requires use of same physics suite in each core
- Use of RUC initial conditions (clouds, assim of sfc obs, etc.)

Contributors to WRF-RR core-test evaluation project

Louisa Nance (DTC)
Chris Harrop (GSD-DTC)

Ligia Bernardet (DTC-GSD)
Meral Demirtas (DTC)

James Pinto (NCAR-RAL)
Marcia Politovich (NCAR-RAL)
Ben Bernstein (NCAR-RAL)
Paul Herzegh (NCAR/RAL)
Richard Bateman, Jenny Simard (NCAR/RAL)
Roy Rasmussen (NCAR/RAL)
Greg Thompson (NCAR/RAL)

Bob Sharman (NCAR/RAL)

Rod Frehlich (NCAR/RAL)
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Wei Wang (NCAR/MMM)
Dave Gill (NCAR/MMM)

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Jennifer Mahoney (ESRL/GSD)
Andy Loughe (GSD-DTC)

Steve Koch (DTC)
Robert Gall (DTC)

Nelson Seaman (NWS)

Matt Pyle (NCEP/EMC)
Brad Ferrier (NCEP/EMC)
Tom Black (NCEP/EMC)
Hui-ya Chuang (NCEP/EMC)

Goal for RR core test

-- two sets of physical parameterizations

(GFDL radiation used for both)

- Phase 1 - Default NMM physics (thought to be “easiest”)
- Phase 2 - RUC-like physics

	Phase 1	Phase 2
Explicit clouds	Ferrier	Thompson-NCAR
Sub-grid convection	Betts-Miller-Janjic	Grell-Devenyi
Land-surface	F77 version of Noah (“99” LSM)	RUC-Smirnova
Turbulent mixing	Mellor-Yamada-Janjic	Mellor-Yamada-Janjic

ARW advantages

Major advantages

- Upper-level wind. This is apparent in aircraft verification. Rawinsonde verification (where ARW advantage was even stronger) is considered flawed.
- Lower-troposphere temperature
- Lower-troposphere relative humidity, primarily at 850 hPa, considered to be potentially important for icing and ceiling forecasts.
- Turbulence (see objective verification results)

Secondary advantages

- Community involvement – Currently more significant with ARW testing and applications than with NMM.   This may be different after additional NMM community exposure via DTC, workshops, etc.

NOAA/ESRL/GSD recommendation to NCEP– 1 Sept 2006 Excerpts:

By a slight margin, the ARW core over the NMM core for the initial operational Rapid Refresh implementation .

- Some significant advantages evident for one core or the other, dependent on variable or vertical level, with a slight edge for ARW overall, but …
- No strong overall advantage for either.
- GSD will fully support NCEP decision, regardless of which core chosen. We urge your careful consideration of the comparison results in the report.

(**http://ruc.noaa.gov/coretest2/GSD-report.pdf**)

- RUC physics (Grell-Devenyi convection, NCAR-Thompson microphysics) ready to go for either NMM or ARW cores

June 06 - Physics availability **due to** WRF-RR Core-Test Project -- all now in WRF v2.2

	NMM	ARW
Ferrier microphysics	✓	✓
NCAR-Thompson microphysics	✓	✓
MYJ PBL	✓	✓
BMJ conv	✓	✓
Grell/Dev conv	✓	✓
Option 99 LSM	✓	✓
Noah LSM	--	✓
RUC LSM	✓	✓
RUC init conds	✓	✓

NCEP/GSD Agreement on Rapid Refresh - signed 12 September 2007

- **2009 – Initial Rapid Refresh – Phase 1**
  - Model - WRF-ARW, Rapid Refresh physics
  - Data assimilation – GSI with RR-unique enhancements
  - Submitted for operations by Sept 2009

- **2012 – Ensemble Rapid Refresh – Phase 2**
  - 6 members, 3 each using ARW and NMM
  - Model (ARW, NMM) and GSI will use ESMF framework, not WRF framework
  - Model/assimilation systems from GSD and NCEP

RUC to Rapid Refresh

- CONUS domain (13km)
- North American domain (13km)

- RUC model
- WRF model (ARW dynamic core)

- RUC 3DVAR
- GSI (Gridpoint Statistical Interpolation)

Transitioning to operations (For RR, as has been for RUC)

- Code must run at NCEP
- Must run within available computer resources and time constraints

  (RUC - 5 min – assim, 17 min- 12h fcst)

- Must be built into existing code infrastructure (e.g.: Build assimilation capability within GSI, develop hourly probabilistic forecast products within NCEP SREF framework)

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Rapid-Refresh Model Configuration and Testing

Tanya Smirnova
Georg Grell
Steven Peckham
John Brown

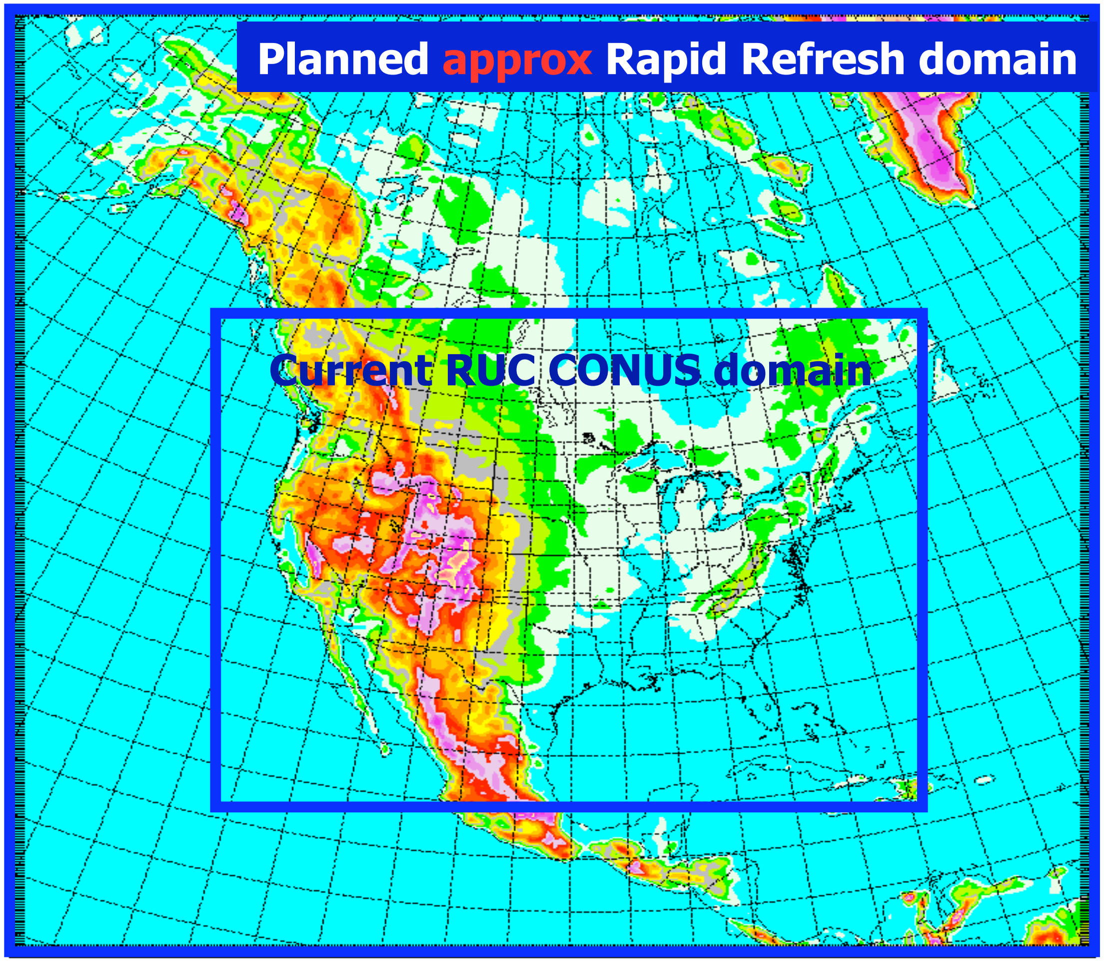
WRF-ARW Configuration
Physics
New GSD Digital Filter Initialization

Rapid-Refresh Domain and Grid

Constraints on domain

- Continental Alaska plus coastal margins
- Dutch Harbor in Aleutians
- Isthmus of Panama
- US Virgin Islands and most of Caribbean

Lambert-Conformal
649 X 648 X 50 layers
Δx = 13.5km
Δt = 60s



WRF Model Configuration

WRF-ARW v2.2 (Dec 06, plus later repository enhancements)

Some namelist options:

- w_damping on - precaution against CFL violation in vertical
- No 6th order diffusion
- Smagorinsky first-order closure for horizontal diffusion
- Upper level wave-damping layer
  - Effective in top 5km
  - dampcoef = 0.02 (same as core test)
- 3-d divergence damping
- External-mode damping
- 5th order horizontal advection, 3rd order vertical advection
  - positive definite for q_v and hydrometeors

default values

RR "RUC-Like" Physics Options

GFDL radiation (l/w and s/w, with cloud effects)

RUC Land-Surface Model => surface fluxes

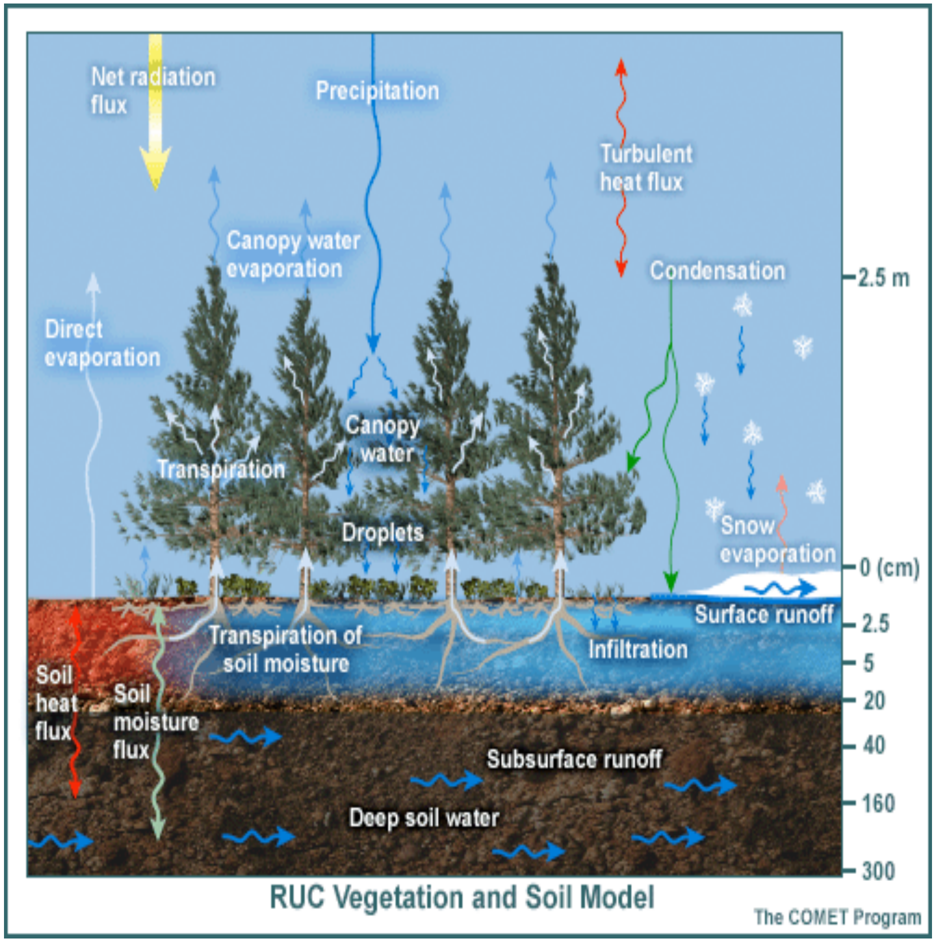
NAM (NCEP) surface layer and turbulent vertical mixing above surface layer

Grell-Devenyi convection

NCAR-Thompson microphysics

This is very similar to the physics configuration used in Phase 2 of the 2006 RR Core Test

Recent RUCLSM Changes



Increased density of snow on ground to ≥100 kg/m3 (from ≥50 kg/m^3) to reduce cold bias over fresh snow cover when temps are ≤ -15C.

Performance of RUCLSM as compared with Noah (NAM) LSM for 2-m temperature in snowmelt conditions is under investigation by DTC in collaboration with RR developers.

Grell-Devenyi Convection

Problems in operational RUC

- Excessive coverage of small precipitation amounts
- Heating-induced convective initiation too early in the day
- Despite detrainment of cloud hydrometeors, seldom initiates much grid-scale precipitation (drying at mid levels)
- Cold pools too weak; too slow (or nil) propagation of convective systems
- Fundamental issue: scale-separation between convection and larger scales (fundamental assumption) becomes less distinct at $\Delta x \leq 20$km.

Grell-Devenyi Convection

Changes to address these issues

Reduce weight given to Arakawa-Schubert closure => helps a little the high bias of small amounts

Require smaller CIN for convective initiation => convection starts later

No longer treat individual grid columns independently: spread "compensating subsidence" into adjacent grid columns => contributes to more realistic initiation of grid-scale precip (and associated subcloud evaporation and cooling).

These will be introduced into RR version of Grell-Devenyi scheme

Grell-Devenyi Convection

Problems in Oct-2007 NCEP operational RUC

- **Excessive coverage of small precipitation amounts**
- **Heating-induced convective initiation too early in the day**
- **Despite detrainment of cloud hydrometeors, seldom initiates much grid-scale precipitation (drying at mid levels)**
- **Cold pools too weak; too slow (or nil) propagation of convective systems**
- **Fundamental issue: scale-separation between convection and larger scales (fundamental assumption) becomes less distinct at $\Delta x \leq 20$km.**

Grell-Devenyi Convection

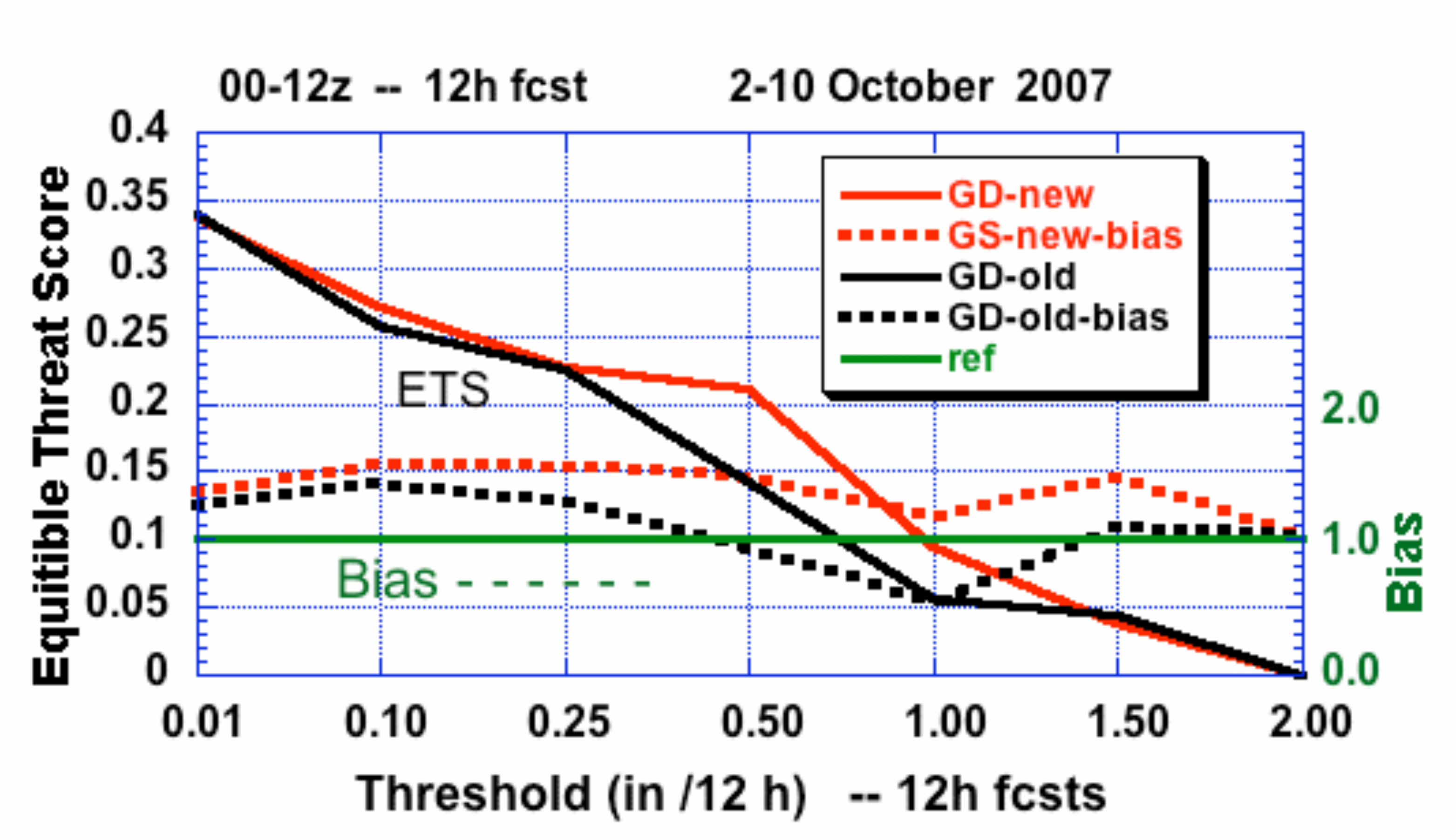
Changes to address these issues

Reduce weight given to Arakawa-Schubert closure
Result: Reduces the high spatial coverage bias of small amounts

Use smaller depth for cap adequate to deny convective initiation
Result: convection starts later in diurnal cycle

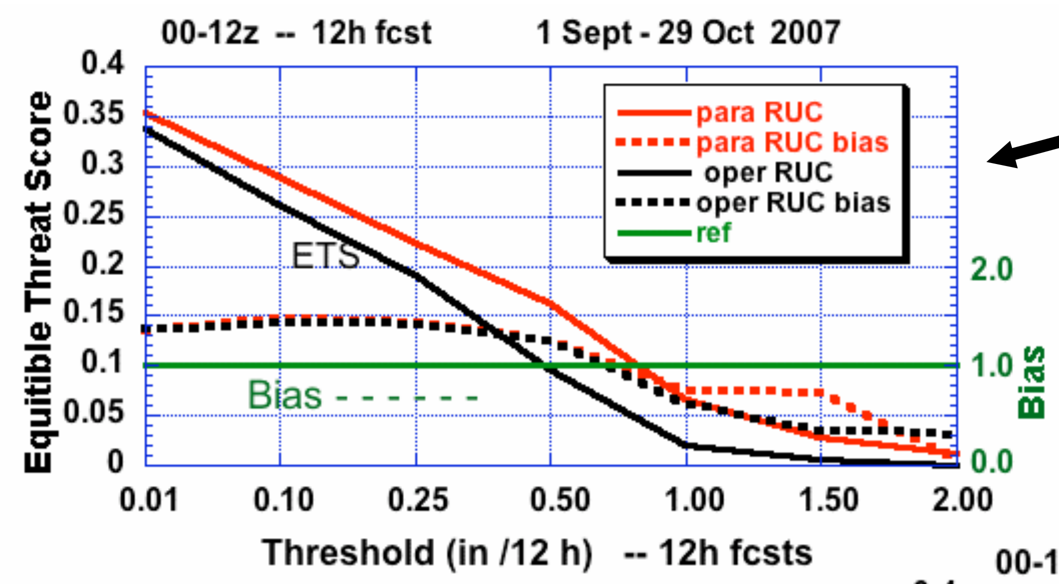
No longer treat individual grid columns independently: spread "compensating subsidence" into adjacent grid columns => contributes to more realistic initiation of grid-scale precip (and associated subcloud evaporation and cooling).

Grell-Devenyi Convection-- effect of non-local subsidence warming



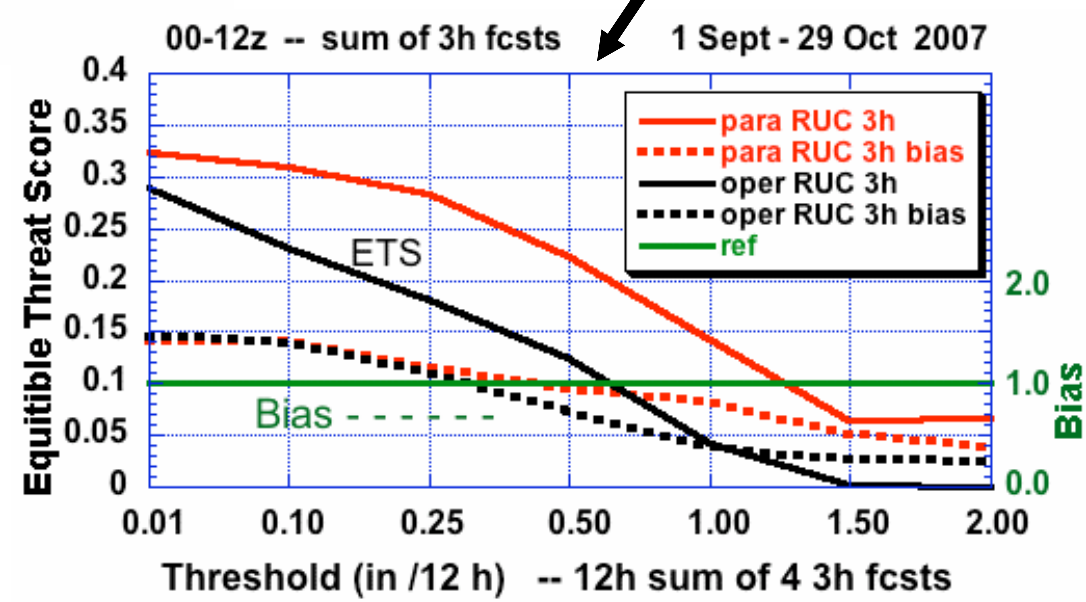
Adds further to the improvement shown on the next slide ….→

Overall improvement in precip forecasts - parallel RUC vs. NCEP oper RUC



12h forecast,

3h forecast



Large improvements due to

- **Radar reflectivity assimilation**
- **Improvements in Grell-Devenyi scheme**
- **Other para changes**

NCAR-Thompson Microphysics

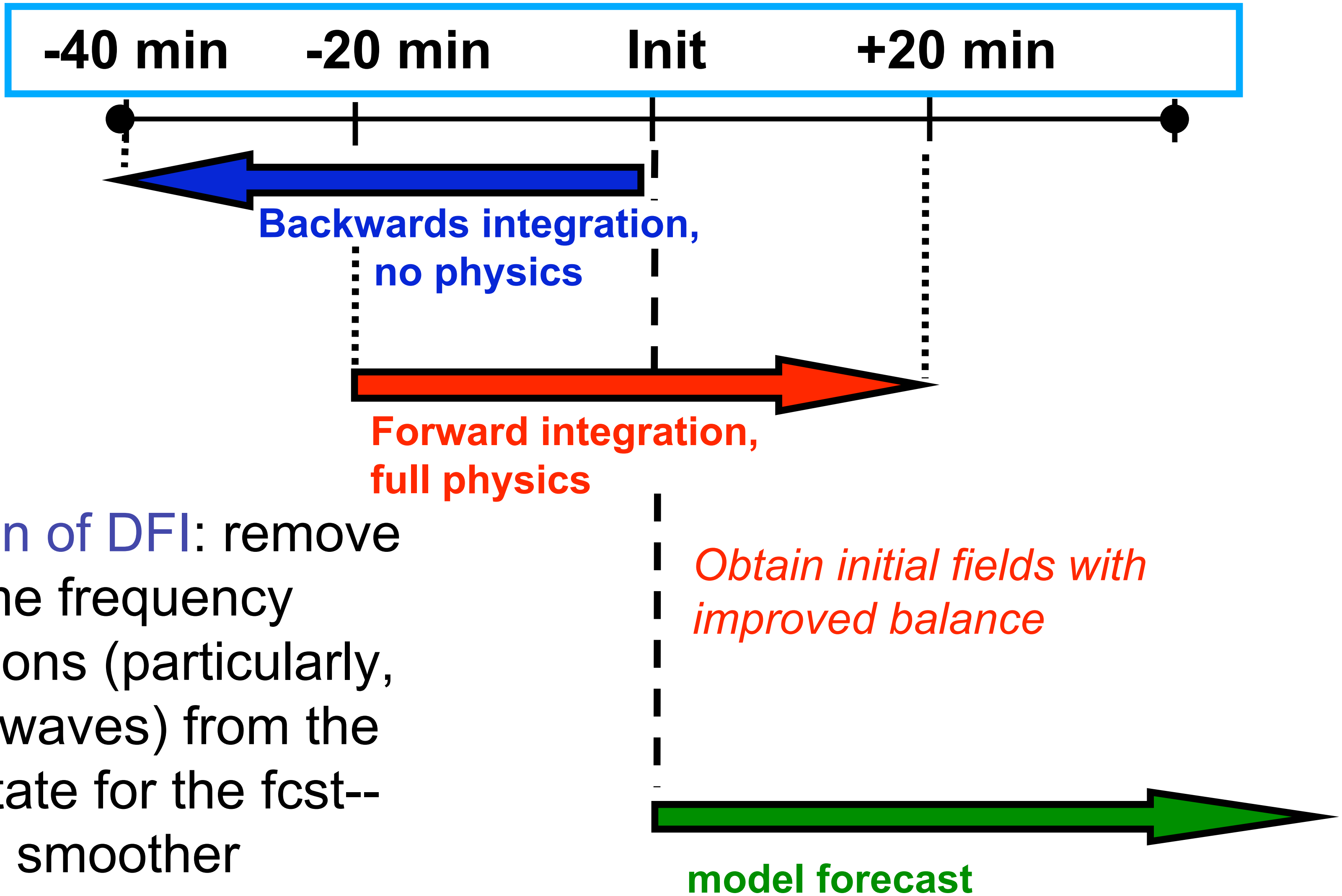
RUC uses Dec 2003 version of scheme

Version in WRF v2.2 (plus more recent bug fixes) has many changes

- Snow particles assumed to be more 2-d than spherical (affects deposition, collision and fall speed)
- Revised collection of snow and graupel by rain
- Rain drop-size distribution depends on estimate of origin of rain (melting snow or collision-coalescence)
- Extensive use of lookup tables
- Gamma distribution for all pcpn hydrometeors

What we have seen: Less graupel than Dec 2003 version, more cloud ice and snow

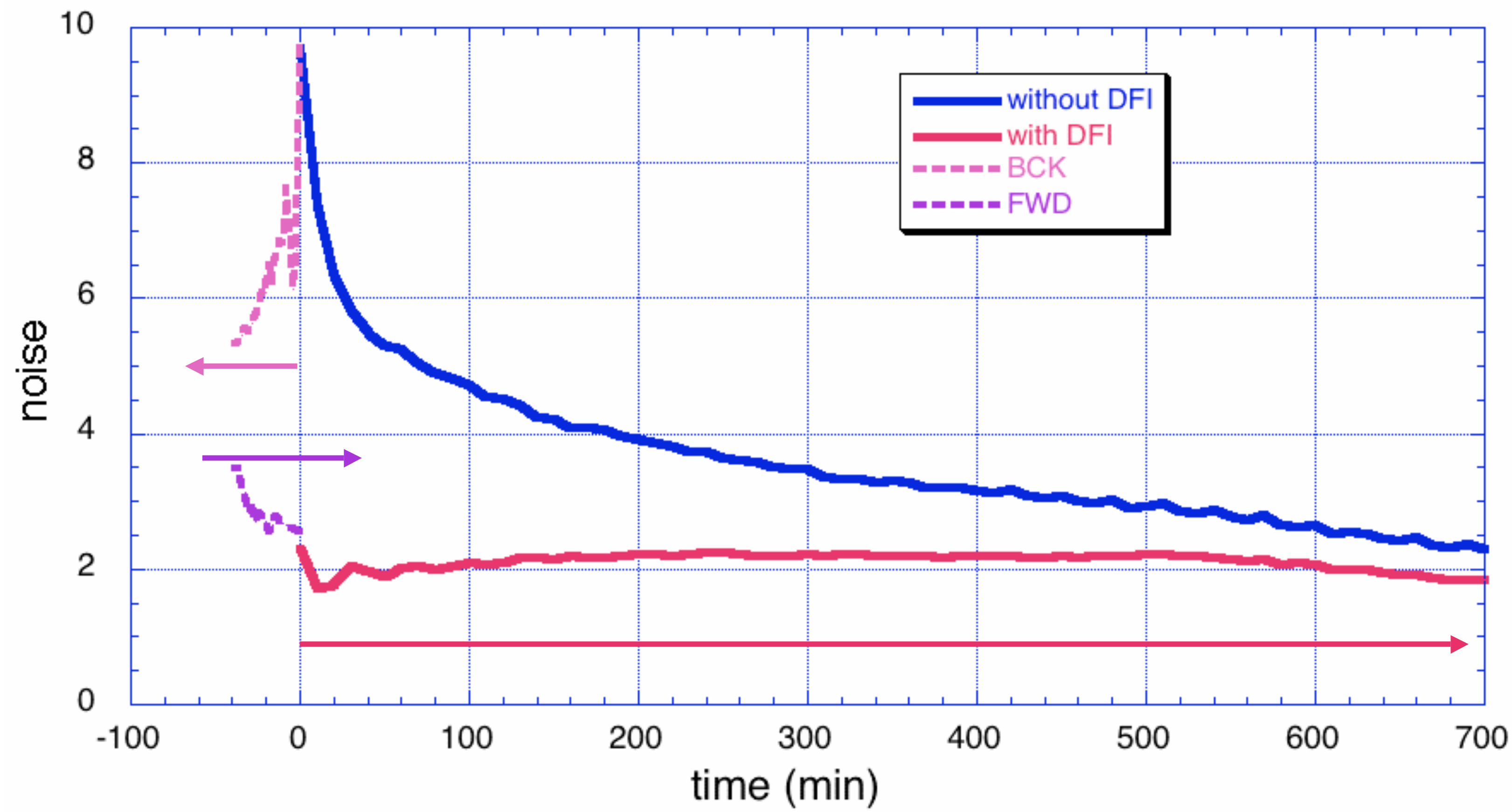
Diabatic Digital Filter Initialization (DDFI)
- Application into WRF - recently completed for ARW
(Tanya Smirnova, Steve Peckham)



Function of DFI: remove high time frequency oscillations (particularly, gravity waves) from the initial state for the fcst-- creates smoother background for next analysis

Noise = mean absolute sfc pressure tendency (hPa/h)

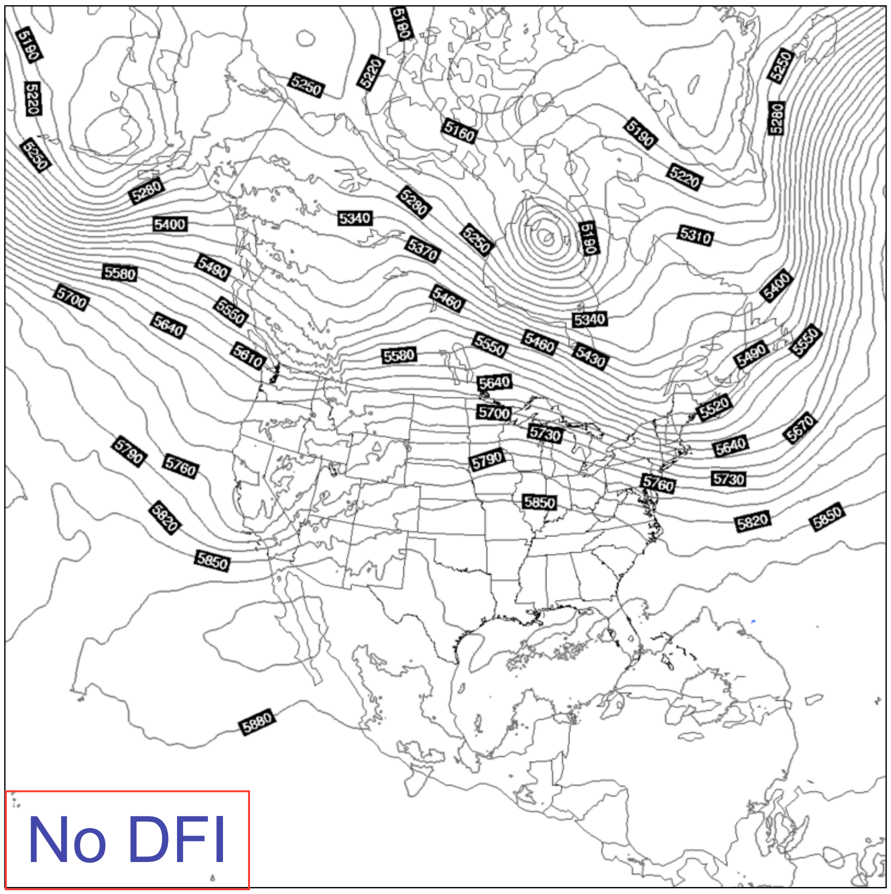
$$\overline{\left|\frac{\partial p_{sfc}}{\partial t}\right|}$$

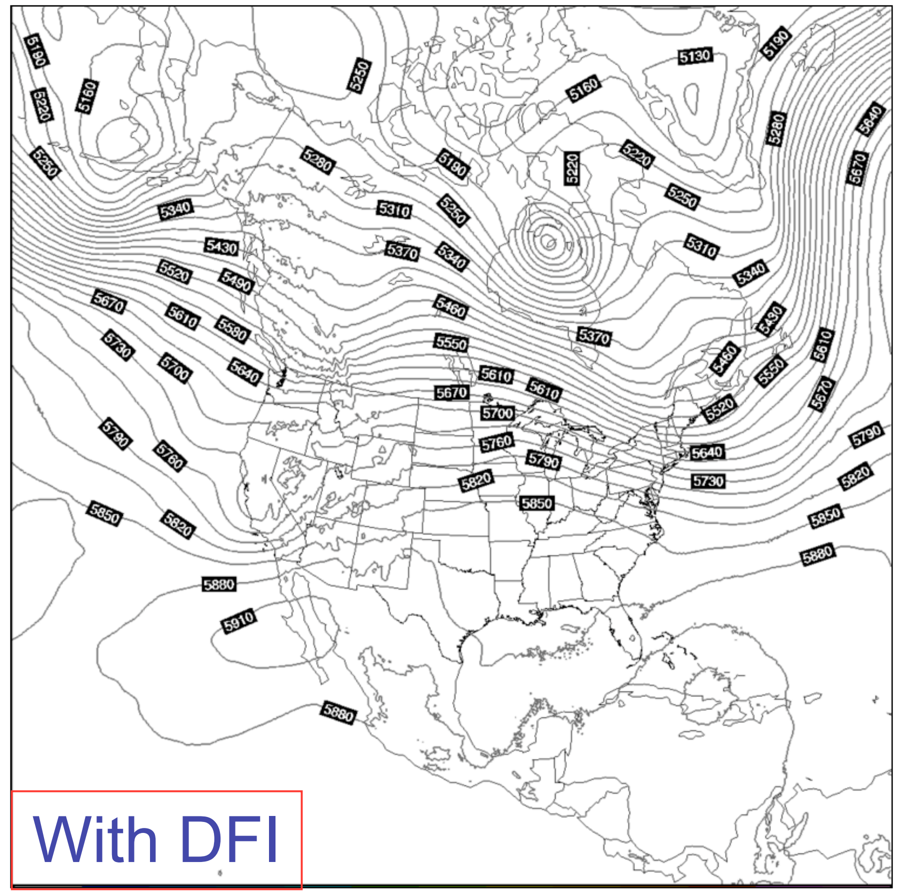


Using WRF-13km Rapid Refresh over N. American domain

500mb Height 3-h Fcst for 03Z 30 Oct 07

Away from terrain and convection, height contours are smoother with DFI





Example of DFI Addition to namelist.input

&dfi_control

- dfi_opt = 1,
- dfi_fwdstop_year = 2007,
- dfi_fwdstop_month = 09,
- dfi_fwdstop_day = 05,
- dfi_fwdstop_hour = 00,
- dfi_fwdstop_minute = 20,
- dfi_fwdstop_second = 00,
- dfi_bckstop_year = 2007,
- dfi_bckstop_month = 09,
- dfi_bckstop_day = 04,
- dfi_bckstop_hour = 23,
- dfi_bckstop_minute = 40,
- dfi_bckstop_second = 00,
- runlength_dfi_fwd = 40,
- runlength_dfi_bck = 40

Code added to wrf.F to accommodate diabatic DFI within a single WRF executable

```
!#ifdef DFI
  if(config_flags%dfi_opt .NE. 0) then

! Initialization for backward integration
    wrf_err_message = ' WRF: Backward Digital Filter turned on '
    CALL wrf_message(TRIM(wrf_err_message))

CALL wrf_DFI_bck_init

    CALL wrf_run

    CALL wrf_DFI_array_reset

! Initialization for forward integration
    wrf_err_message = ' WRF: Forward Digital Filter turned on '
    CALL wrf_message(TRIM(wrf_err_message))
    CALL wrf_DFI_fwd_init

    CALL wrf_run

    CALL wrf_DFI_array_reset

!   if(config_flags%dfi_opt .NE. 0) then

! need to reset config_flags%dfi_opt to 0 for the WRF model run
    CALL wrf_DFI_reset_init
  endif
!#endif

 ! WRF model time-stepping.  Calls integrate().
  CALL wrf_run

  ! WRF model clean-up.  This calls MPI_FINALIZE() for DM parallel runs.
  CALL wrf_finalize
```

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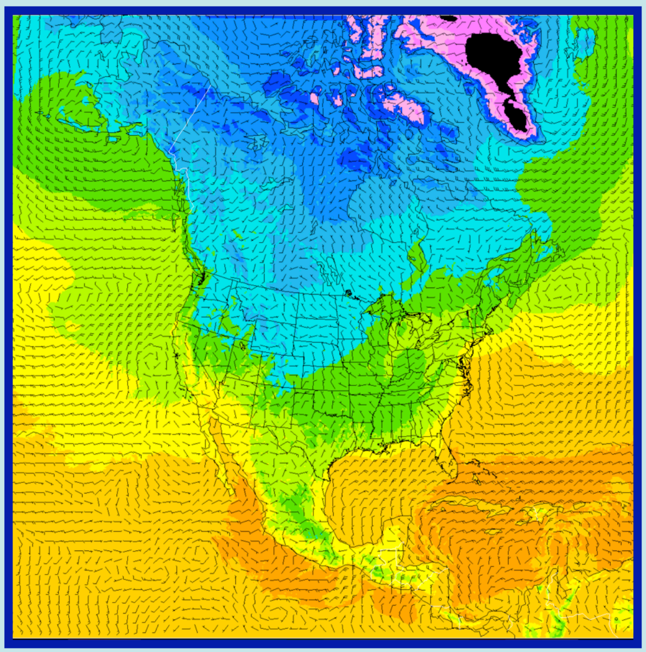
Rapid Refresh assimilation with GSI

Steve Weygandt
Dezso Devenyi
Ming Hu

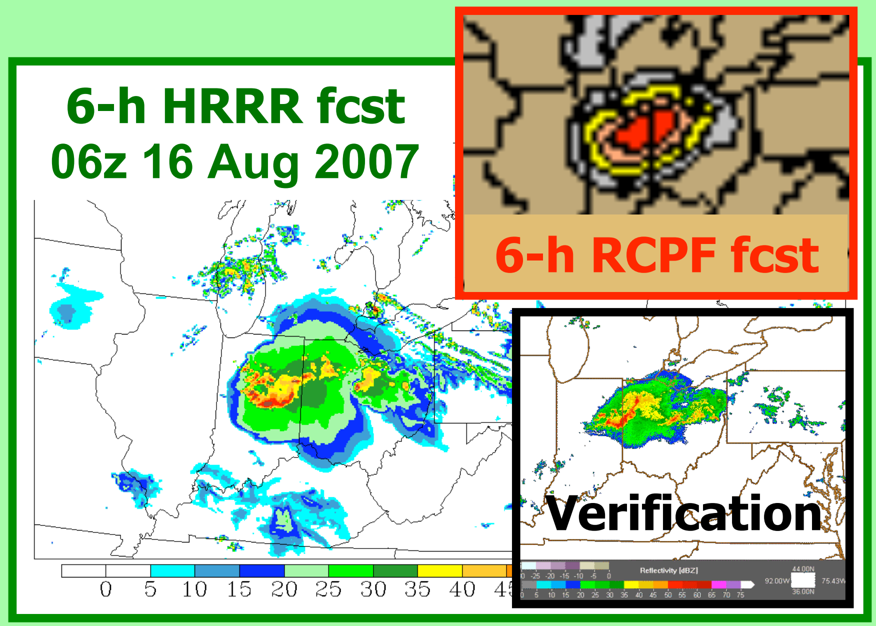
6-h fcst surface temp. 12z 27 Oct 2007

WRF ARW Cycled with GSI



Convection forecasting with HRRR and RCPF

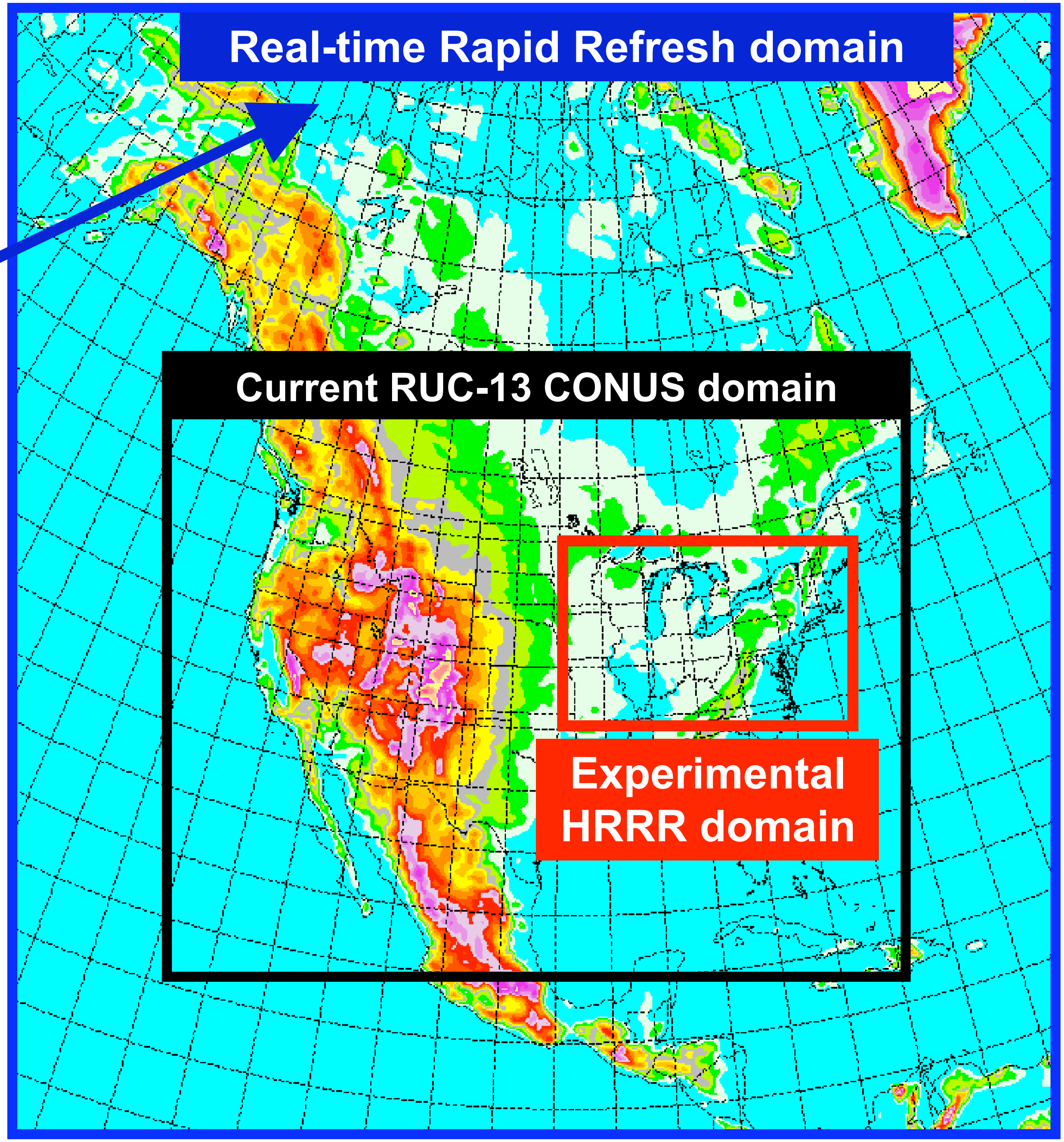
Steve Weygandt
Tanya Smirnova



RUC, Rapid Refresh and HRRR domains

Rapid Refresh domain

- Cycling on full North American domain
- Eventually update every hour, include satellite data
- Consistent hi-res, frequently updated grids for all of North America



Background on GSI for RR
(Gridpoint Statistical Interpolation)

- **Adapted from successful Spectral Statistical Interpolation (SSI) used for global model at NCEP**
  - Used for operational NAM, becoming NOAA unified analysis
  - Collaborative work with NASA, JCSDA (20+ researchers)
- **Includes full satellite radiance assimilation**
- **For expanded RR domain (much ocean area), start with existing, mature analysis system (GSI)**
- **Build in "RR-specific" components:**
  1) 1-h cycling including cloud/precip and LSM fields
  2) Cloud analysis (satellite, METAR, radar, LTG obs)
  3) surface obs assimilation (BL depth, coast-lines)
  4) Force convection from radar, lightning data in model DDFI
  5) Mesoscale error covariances and balance constraints

Use of Satellite Data within GSI

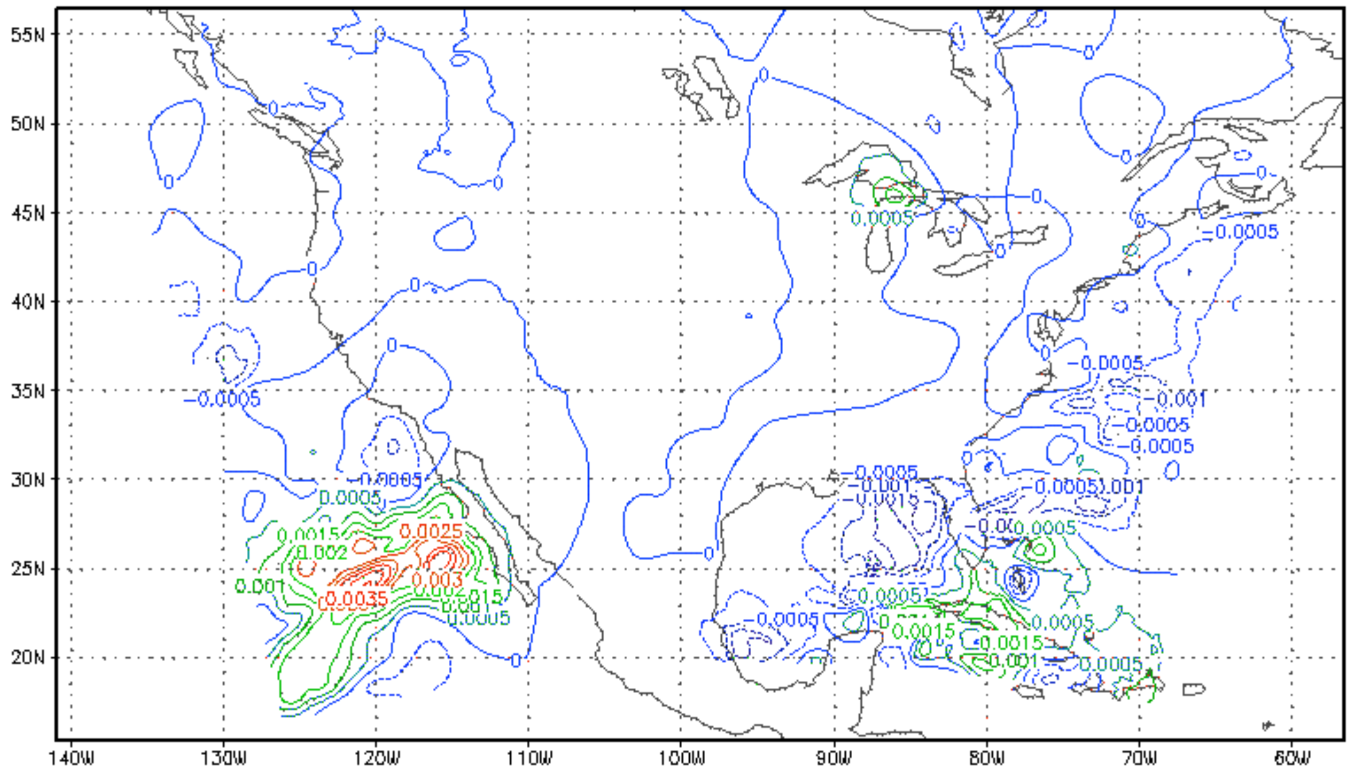
Both HIRS and MSU -- Use of Community Radiative Transfer Model (CRTM)

Preliminary experiments with NAM satellite radiance and bias files over CONUS domain using RUC background fields. Case of 11 April 2006, 1200 UTC.

Difference

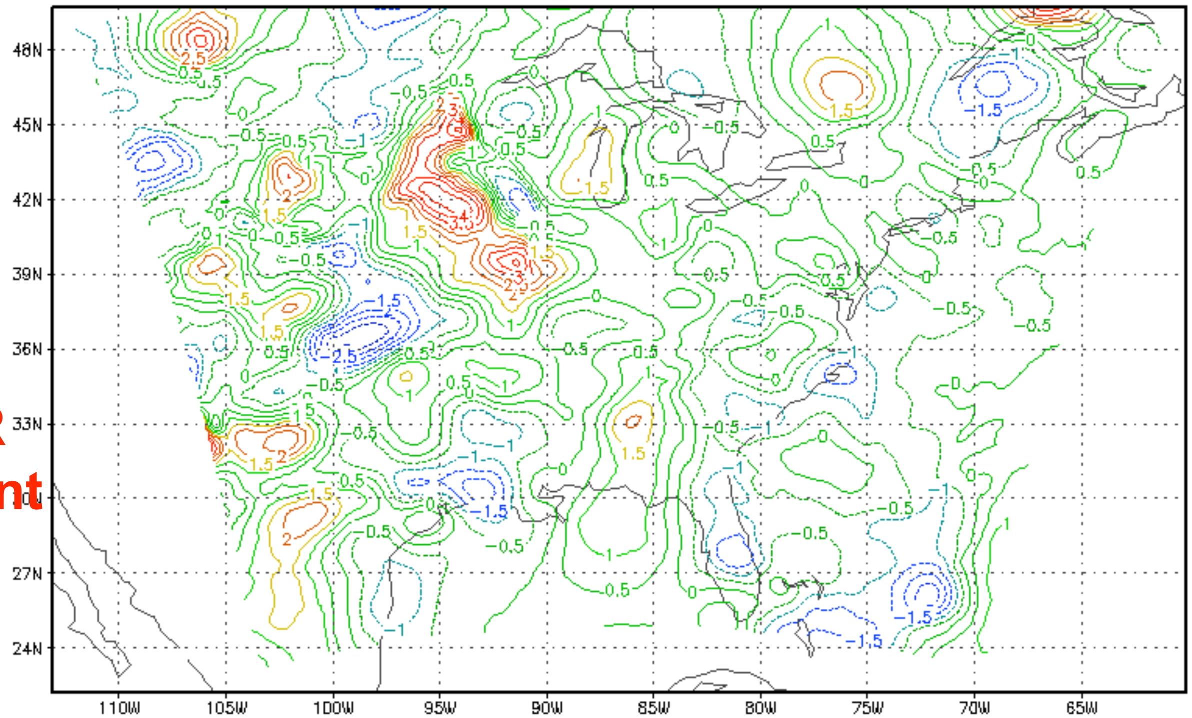
satellite minus no-satellite data; specific humidity.

Model level=10.



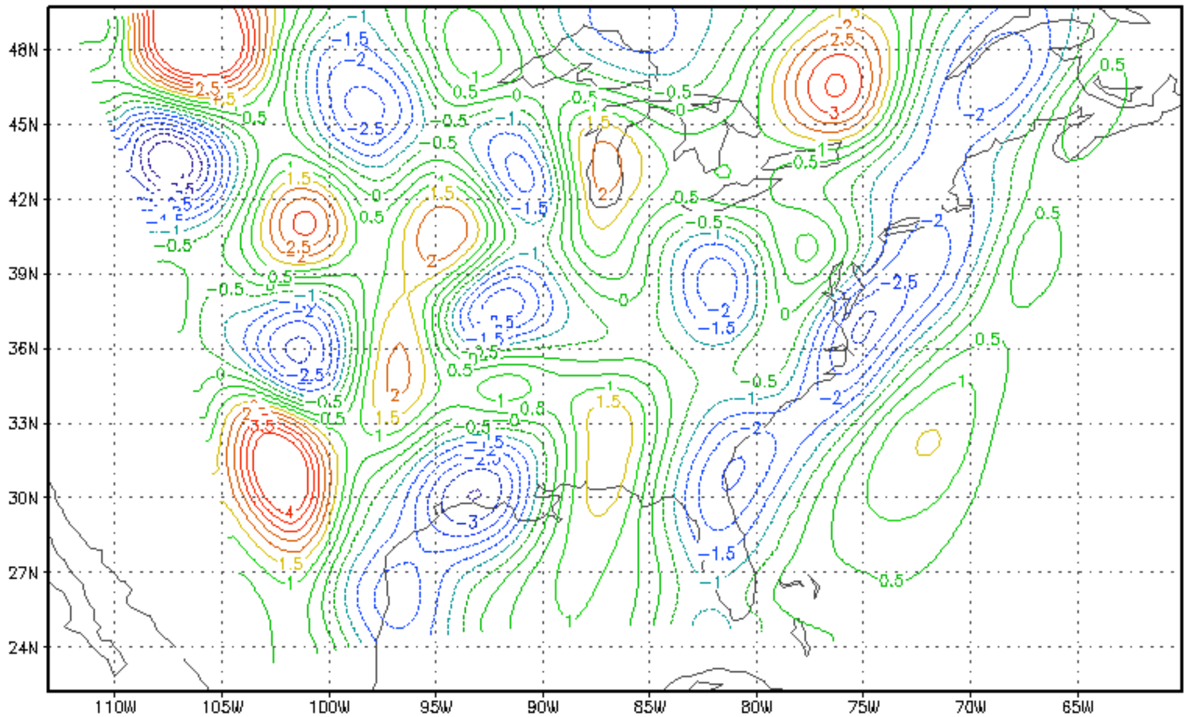
GSI analysis increments (with NAM background error covariances) smoother than RUC

RUC 3DVAR increment

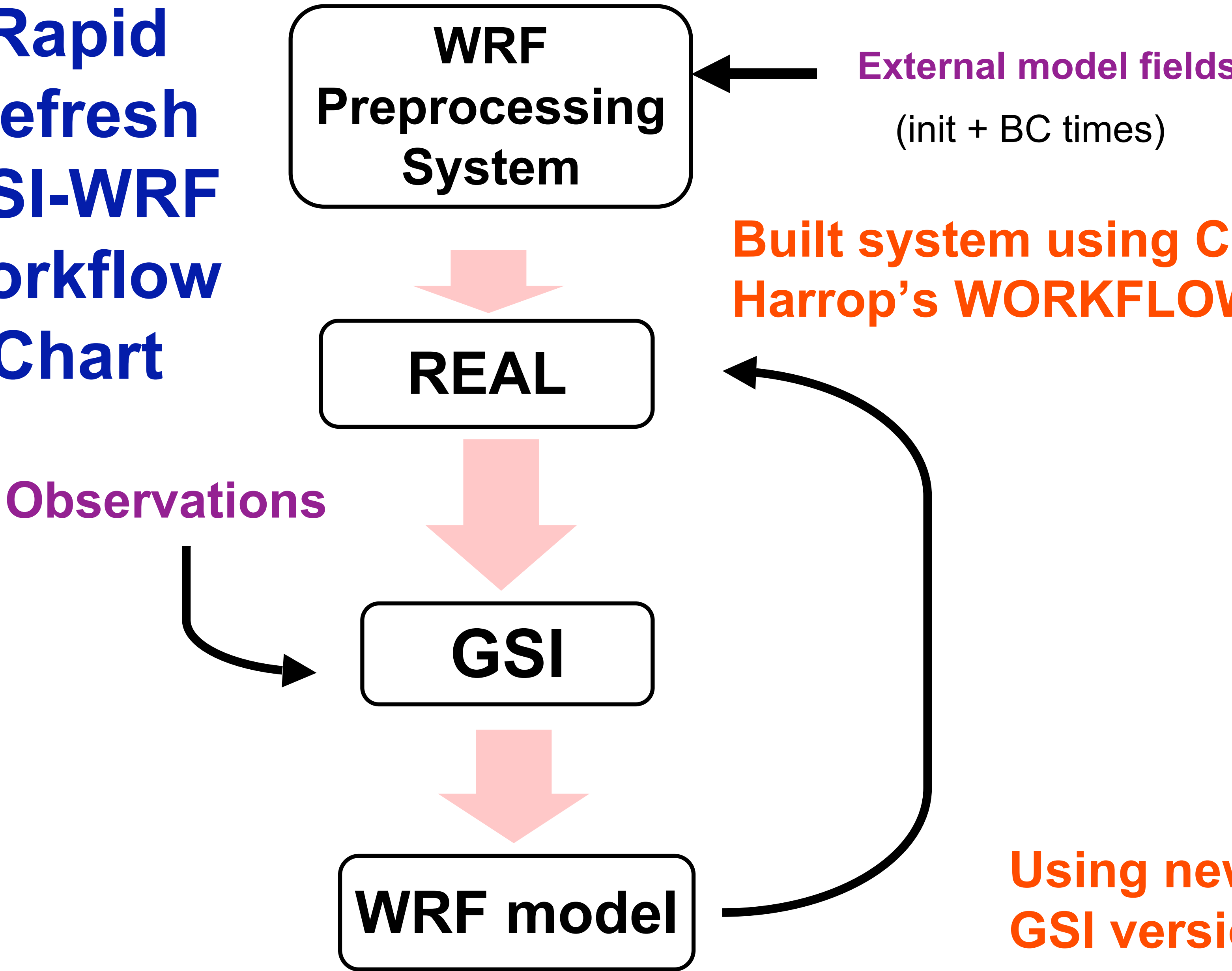


Model level=20 v-component of wind

GSI 3DVAR increment



Rapid Refresh GSI-WRF workflow Chart



Built system using Chris Harrop's WORKFLOW

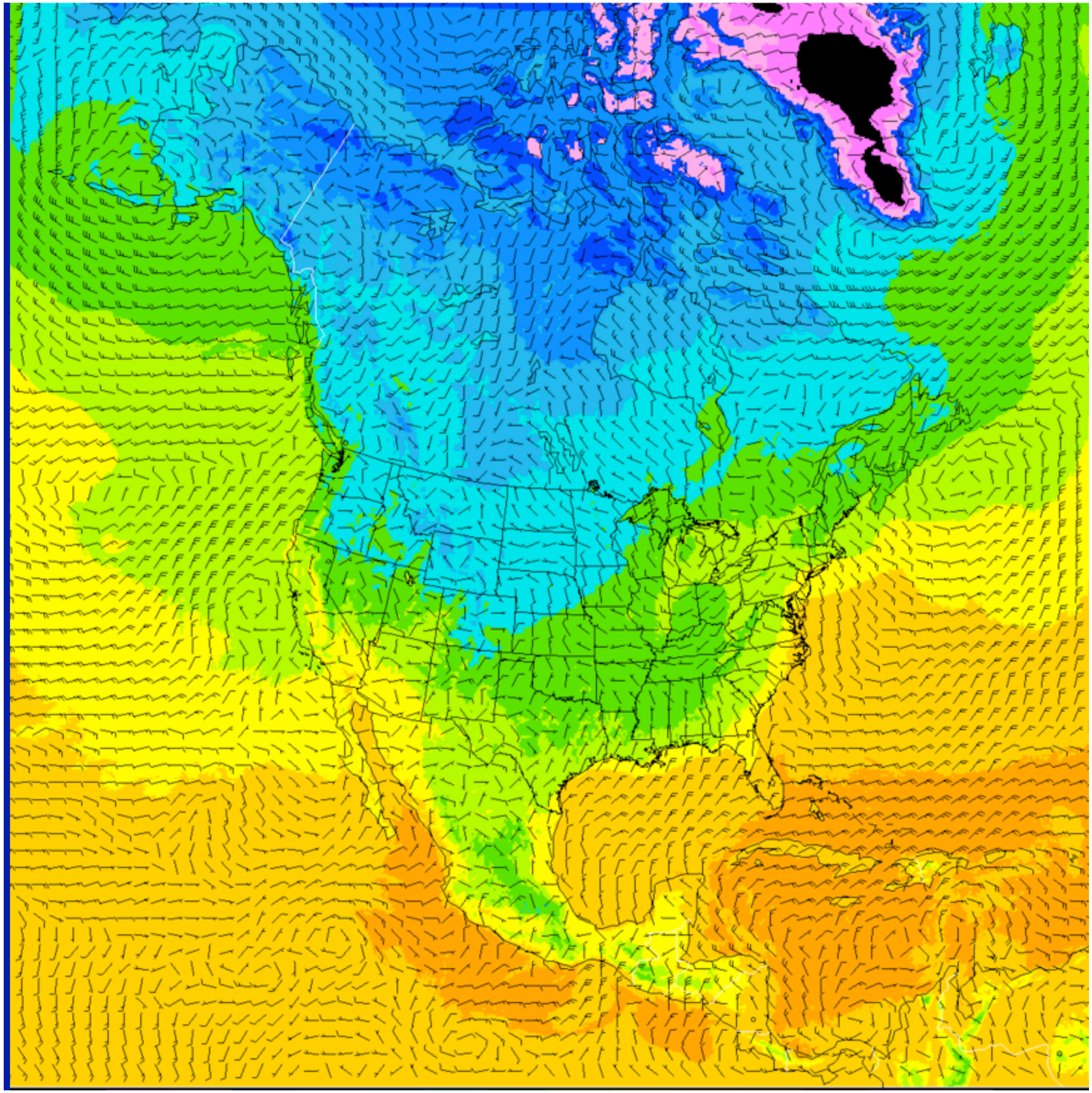
Using new GSI version, WPS, WRFv2.2

Combined Effort to get RR cycle (GSI + WRF) running on wJET

- **Numerous computer issues with GSI**
  - Optimized to work on NCEP IBM supercomputer
  - Significant parallel I/O issues for other computers
  - Major issues from security patch (Aug. 2007)
- **Major effort by numerous people**
  - Jacques Middlecoff, Chris Harrop
  - Leslie Hart and entire jet management team
- **Major progress late Oct. 2007**
  - Updated wjet kernels for MPI (24 Oct.)

Two RR 13-km cycles (6-h full domain, 3-h CONUS domain) running as of 27 Oct.

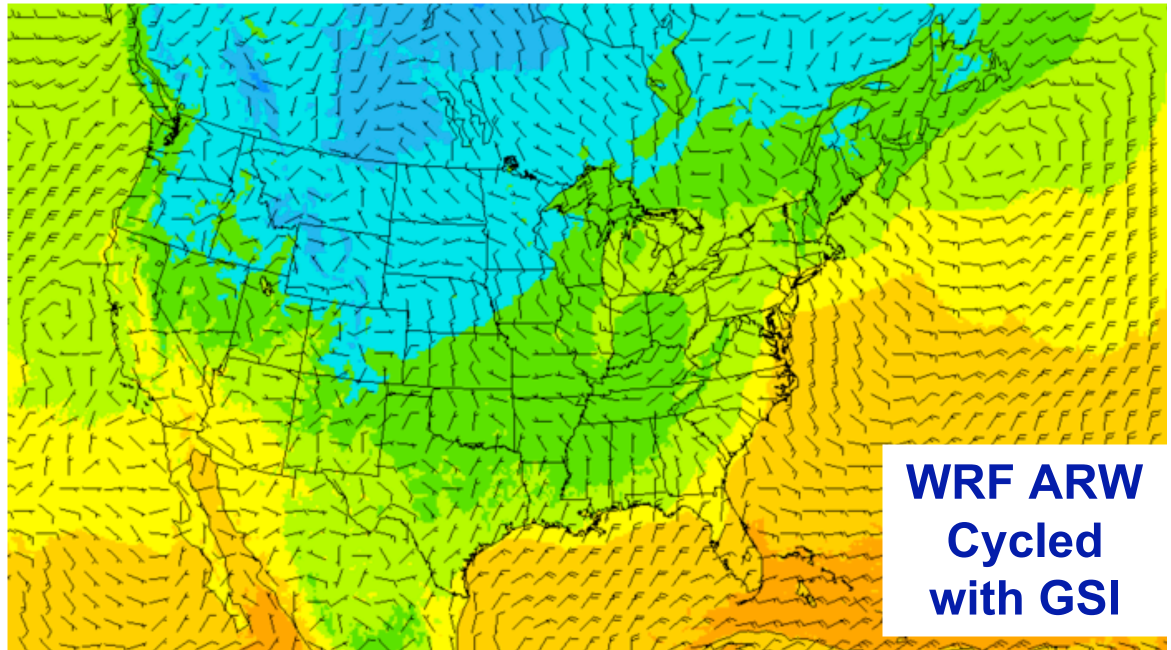
Cycled GSI- WRF forecasts on full Rapid Refresh

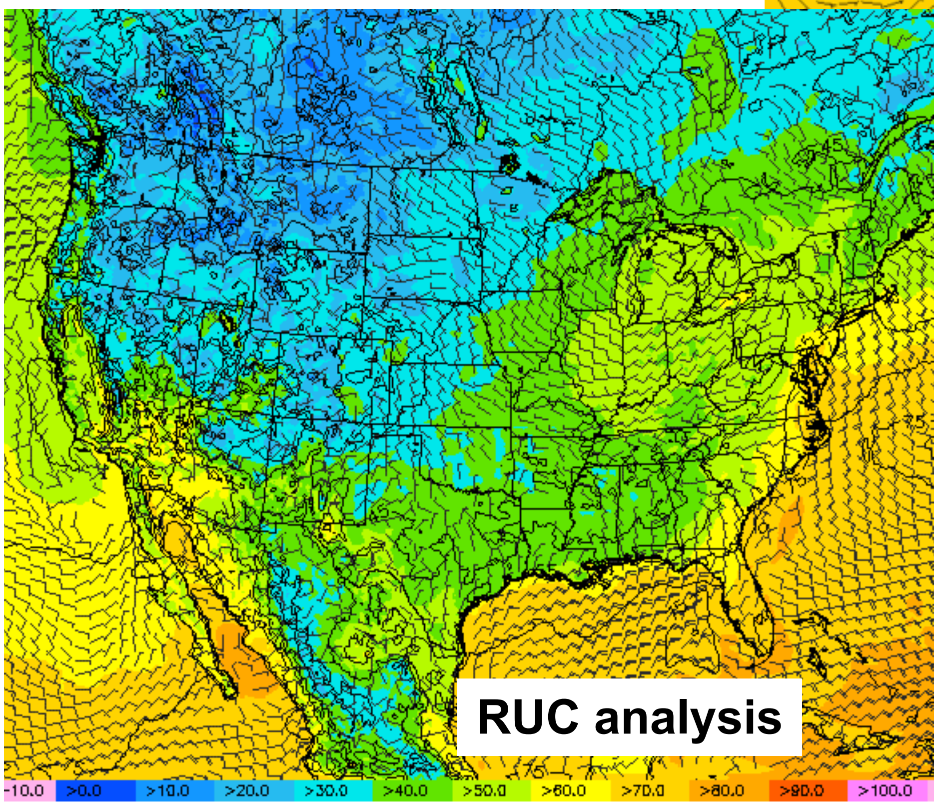


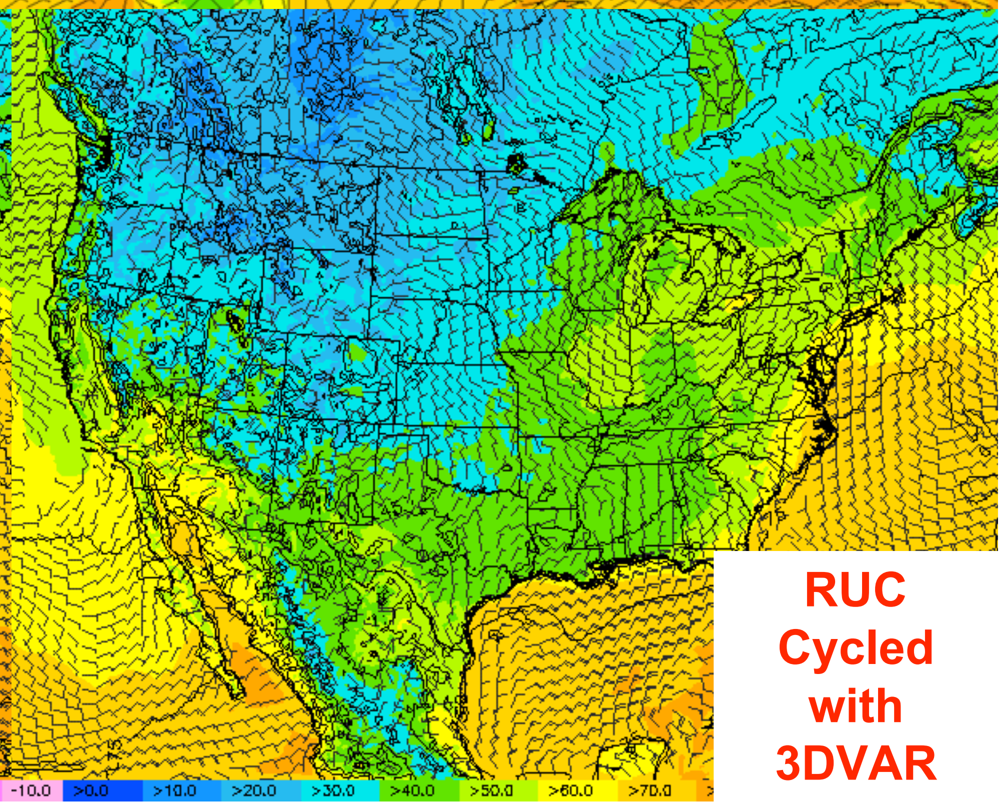
6-h fcst surface Temp. Valid 12z 27 Oct 2007

GSI- WRF cycled forecasts compare with RUC

6-h fcst surface temp. v12z 27 Oct 2007



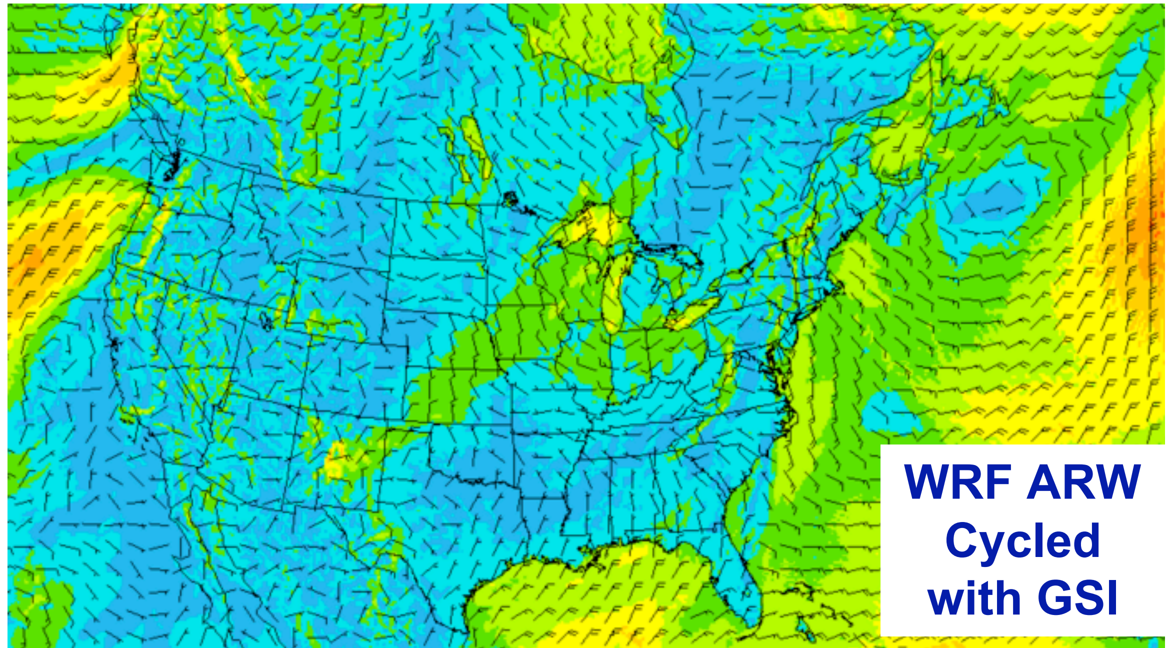




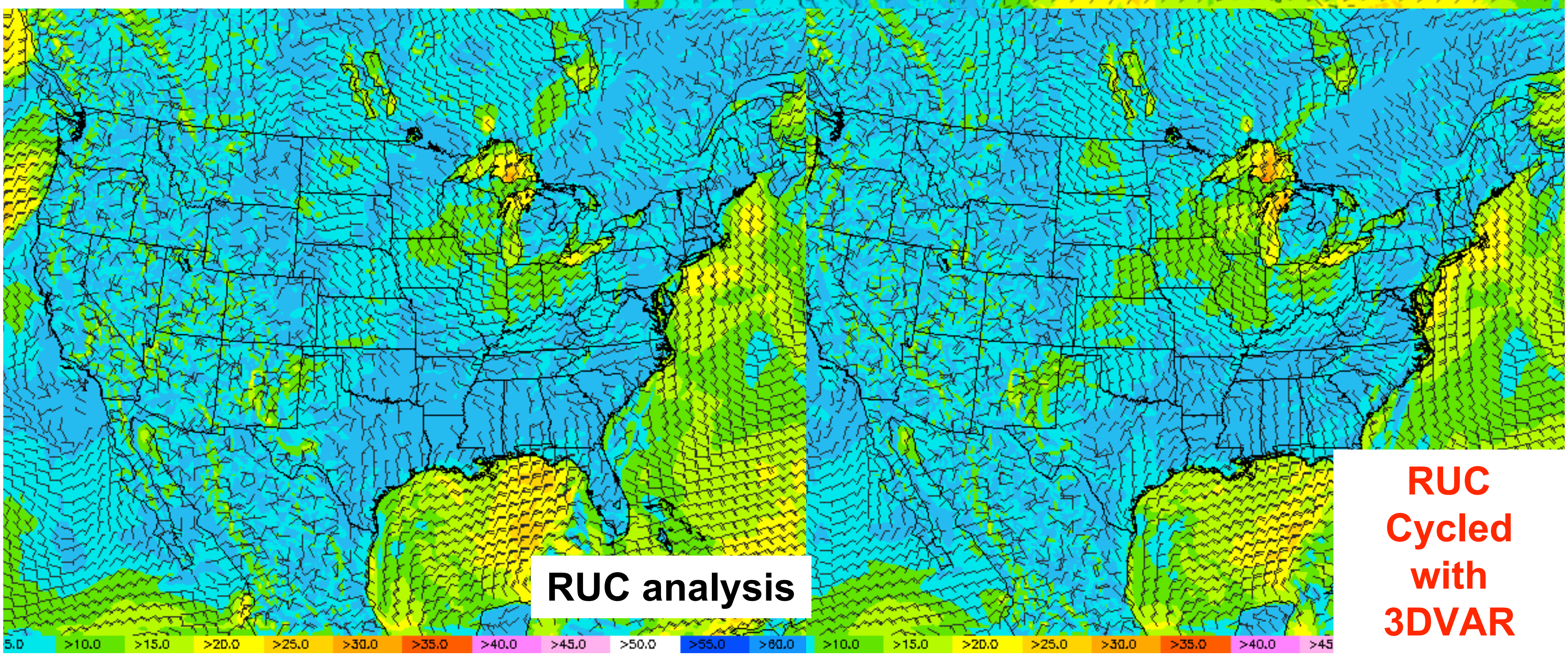
RUC Cycled with 3DVAR

GSI- WRF cycled forecasts compare with RUC

6-h fcst
10-m
wind
valid
12z 27
Oct 2007



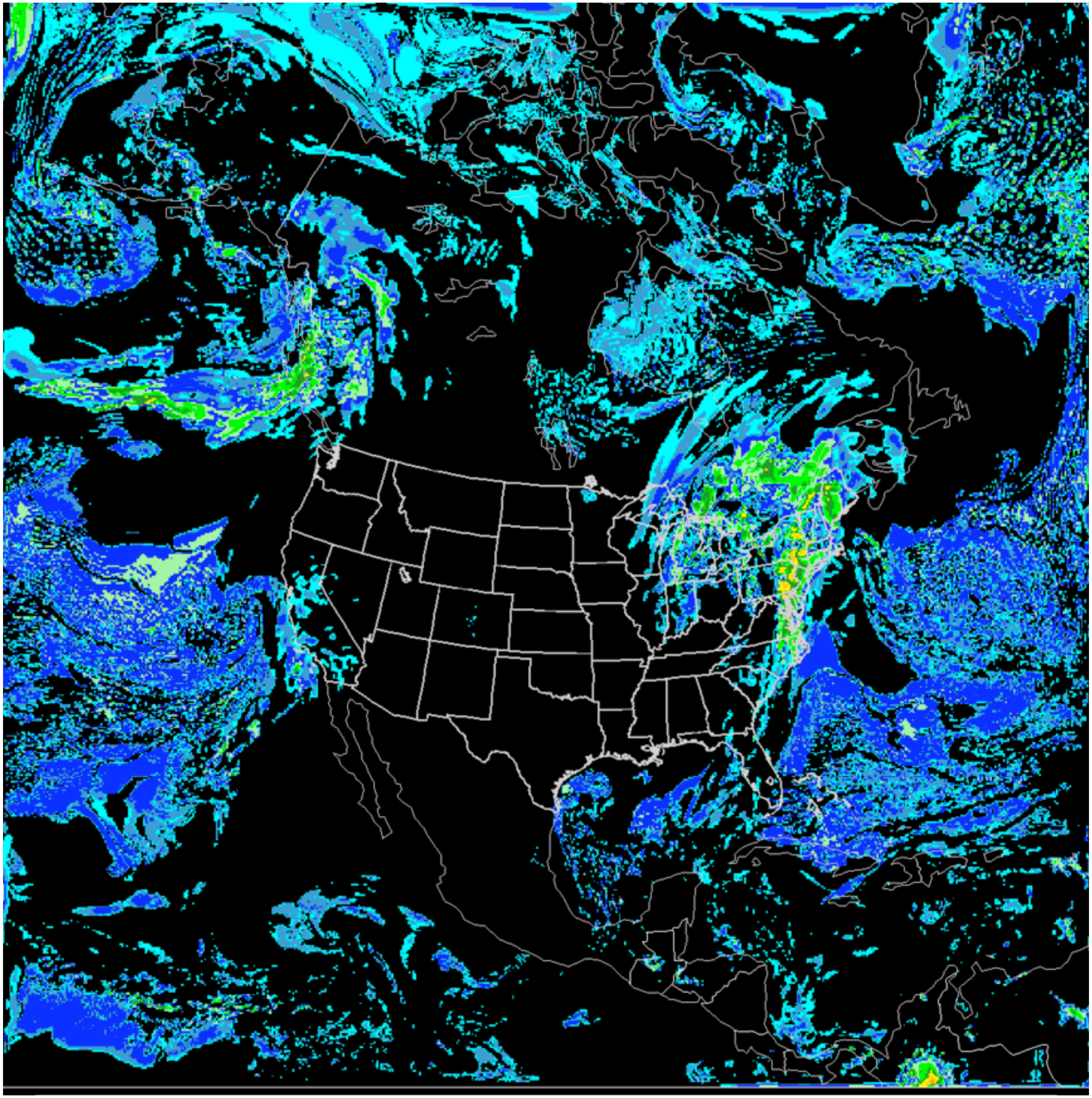
WRF ARW
Cycled
with GSI



RUC analysis

RUC
Cycled
with
3DVAR

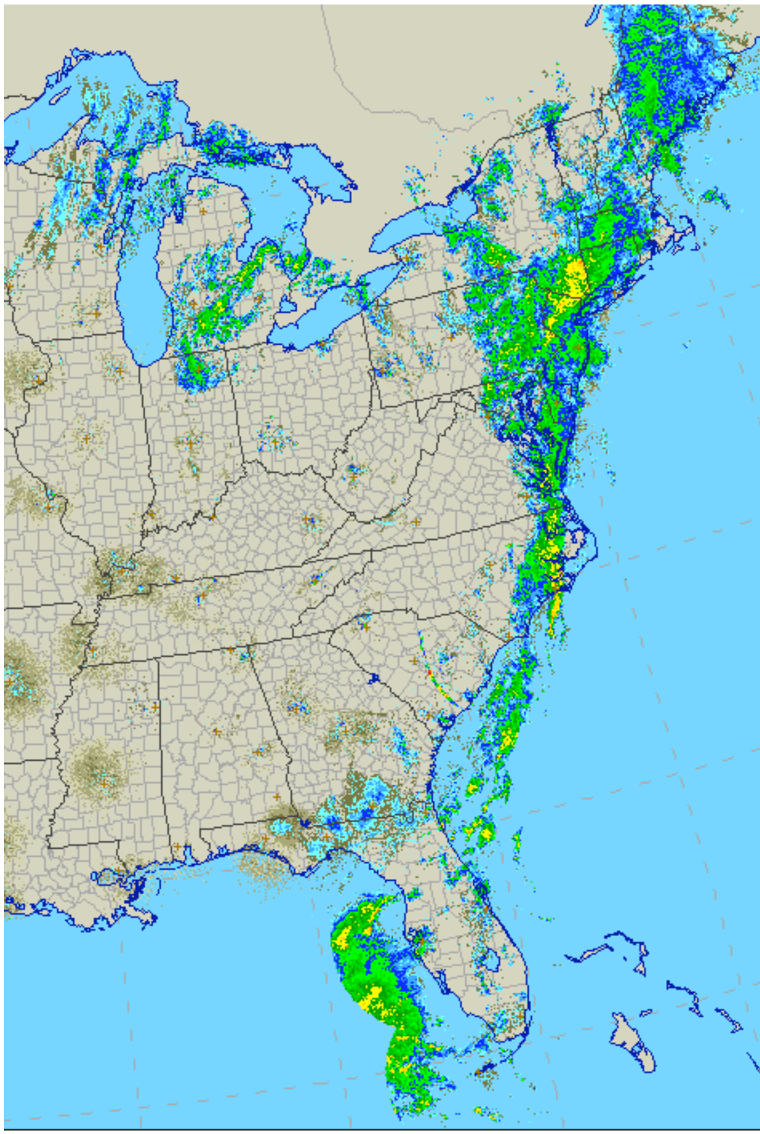
Cycled GSI- WRF forecasts on full Rapid Refresh



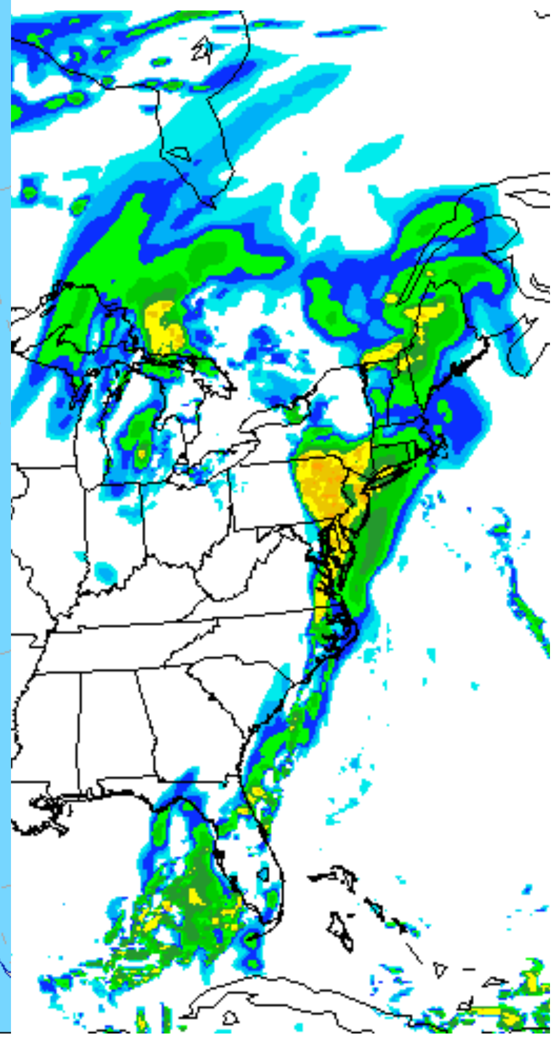
6-h fcst
Composite
Reflectivity
12z 27
Oct 2007

Full Rapid Refresh domain (6-h cycle)

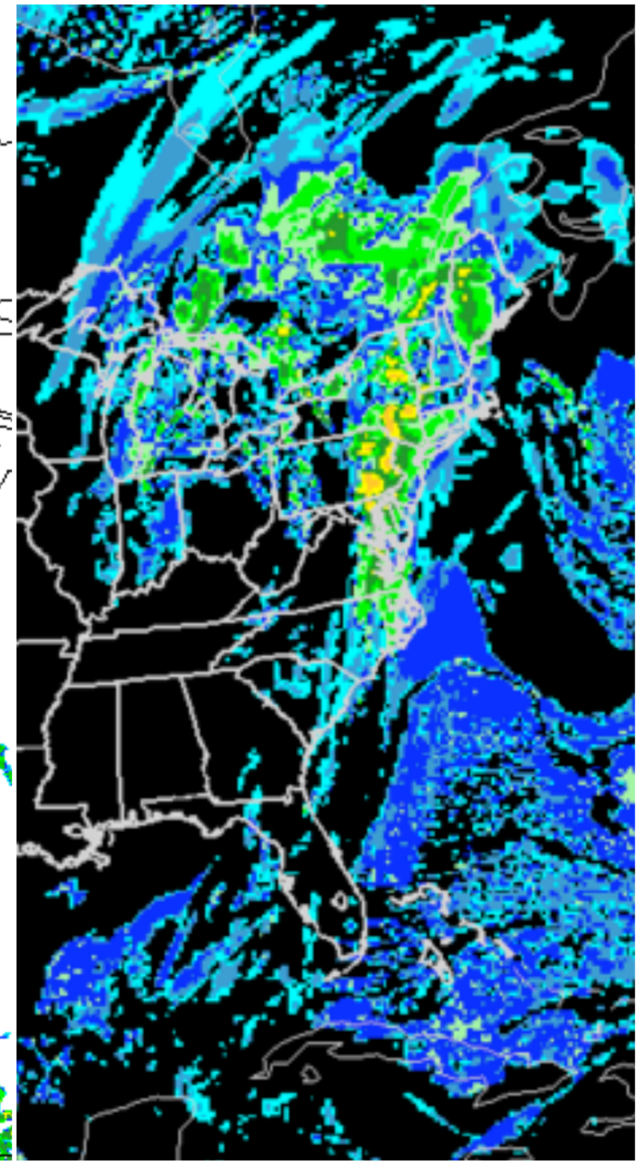
Radar mosaic
12z 27 Oct 2007



RUC cycled
6-h forecast

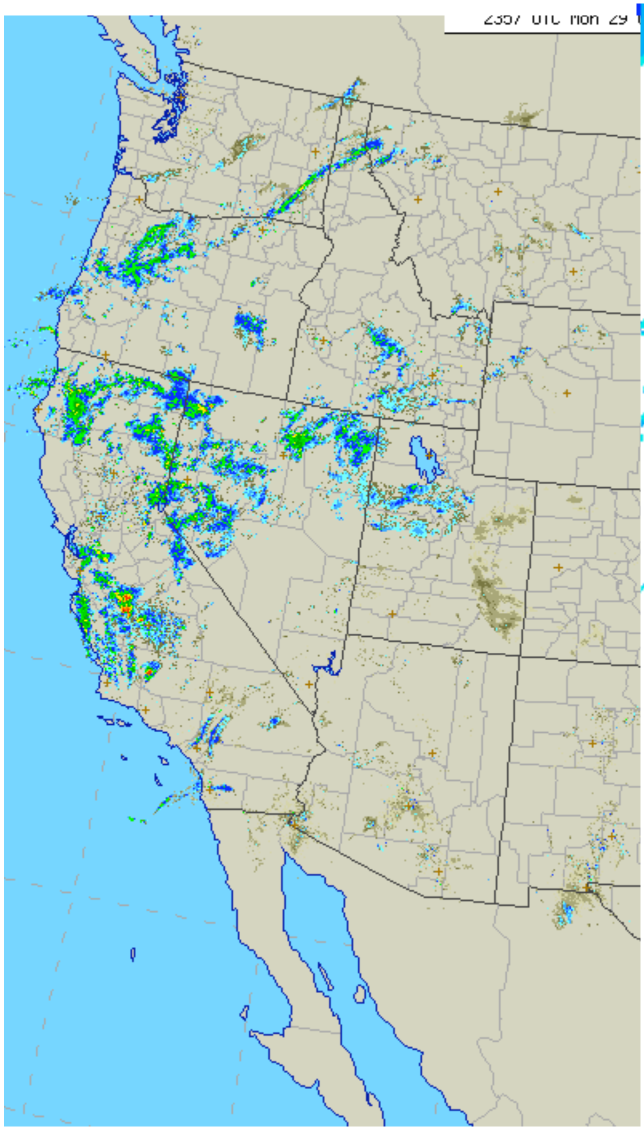


GSI- WRF cycled
6-h forecast

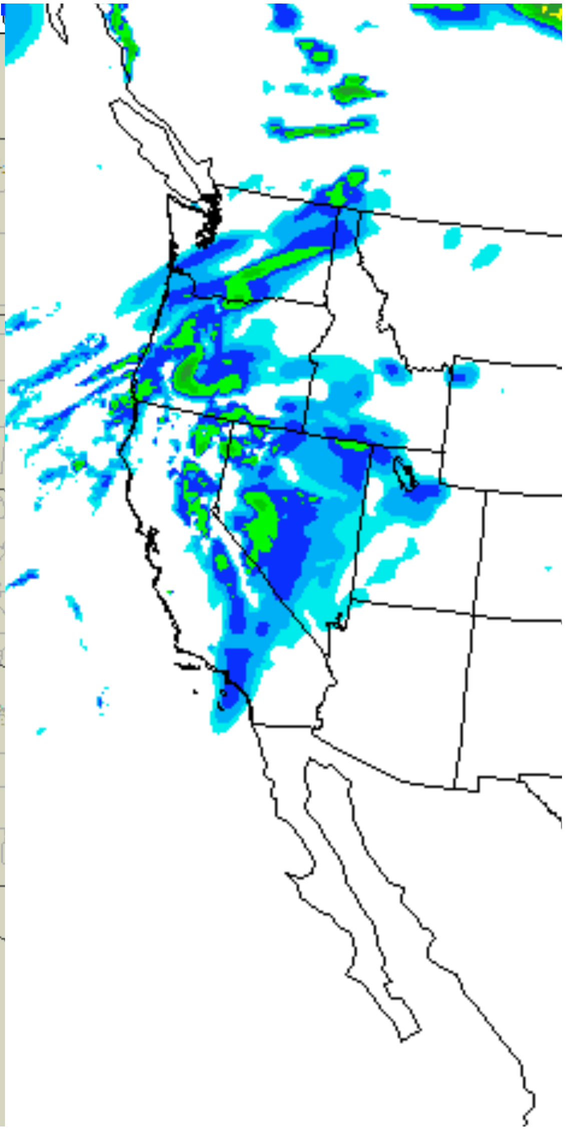


CONUS Rapid Refresh domain (3-h cycle)

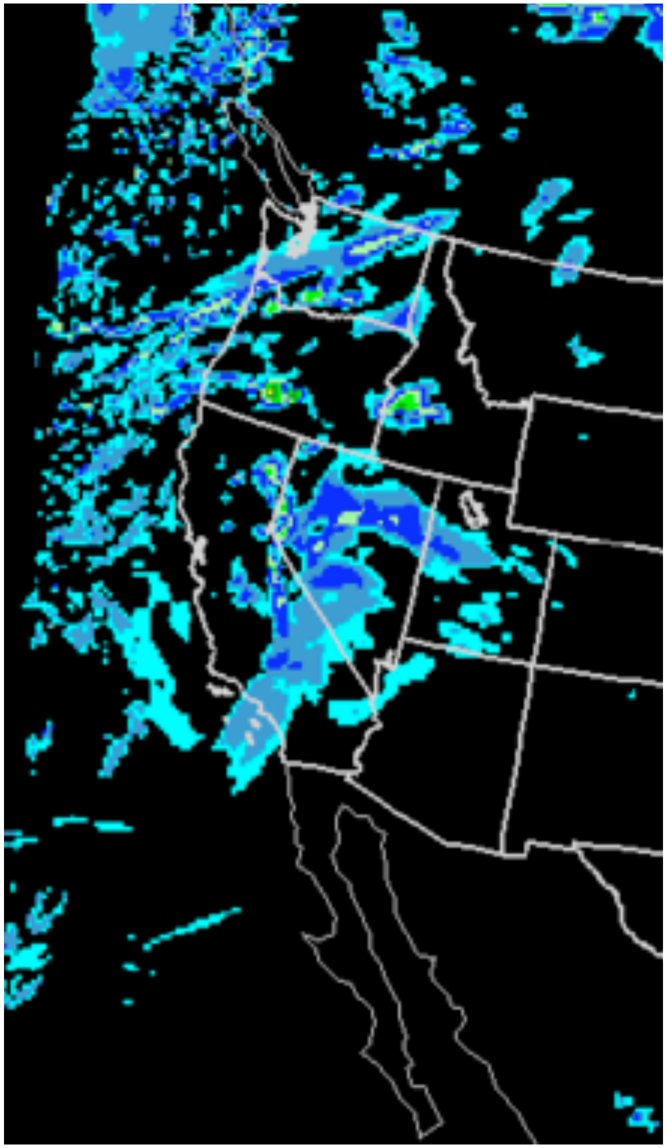
Radar mosaic
00z 30 Oct 2007



RUC cycled
12-h forecast

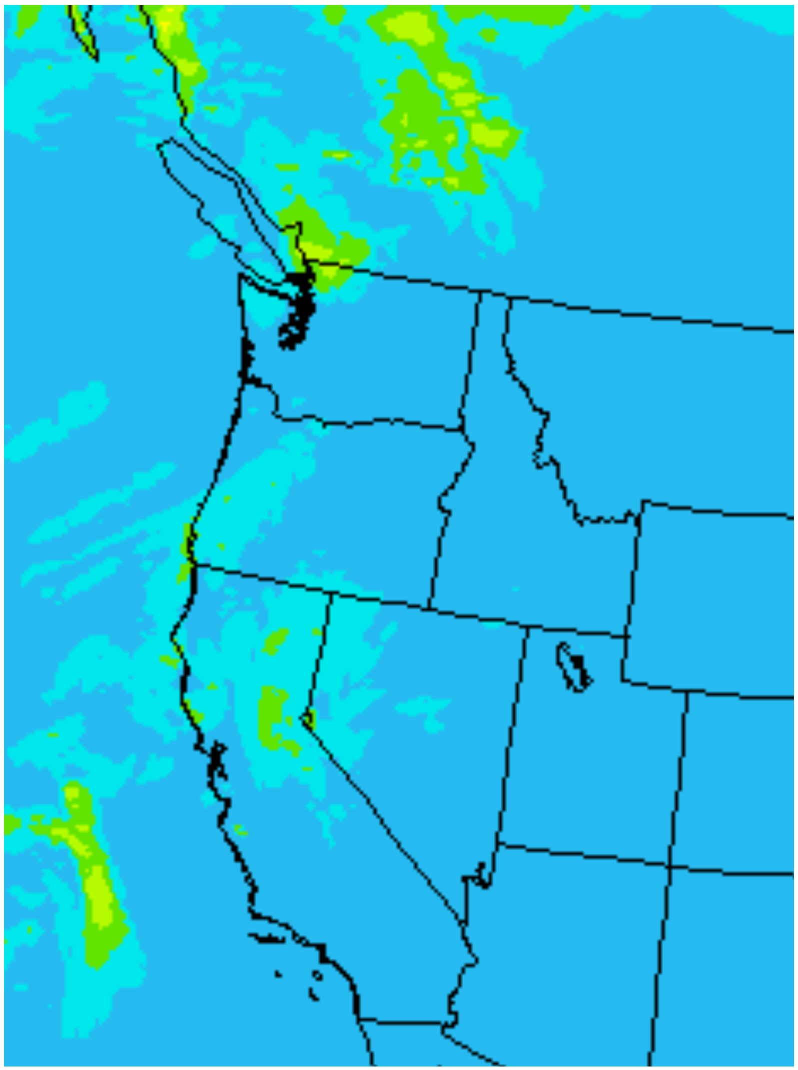


GSI- WRF cycled
12-h forecast

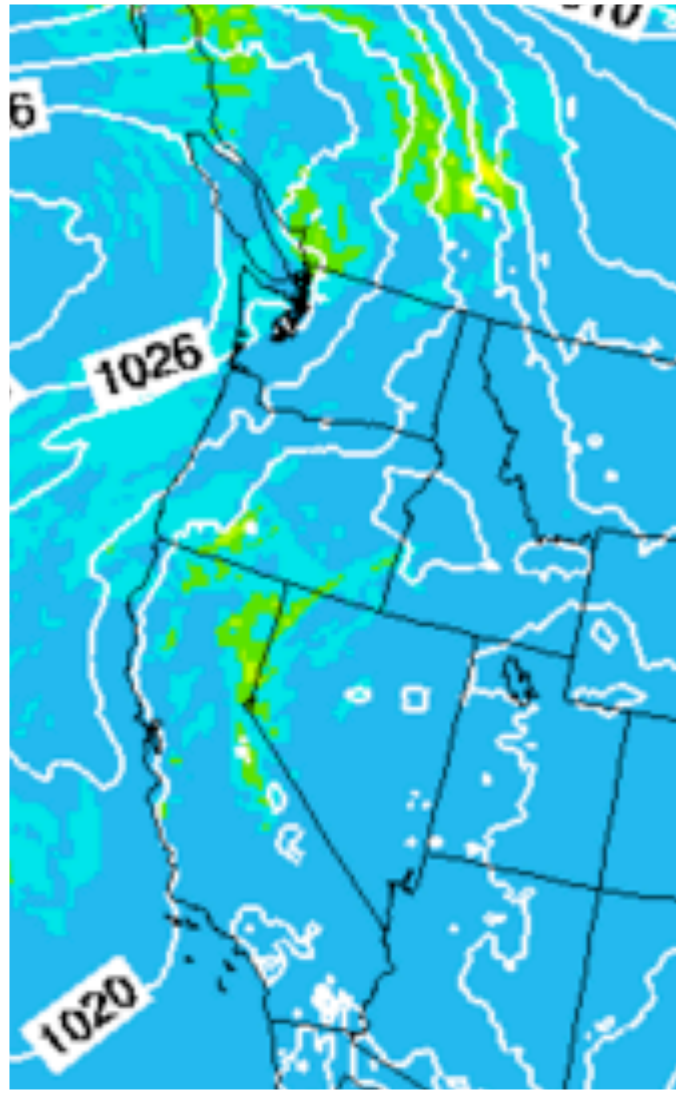


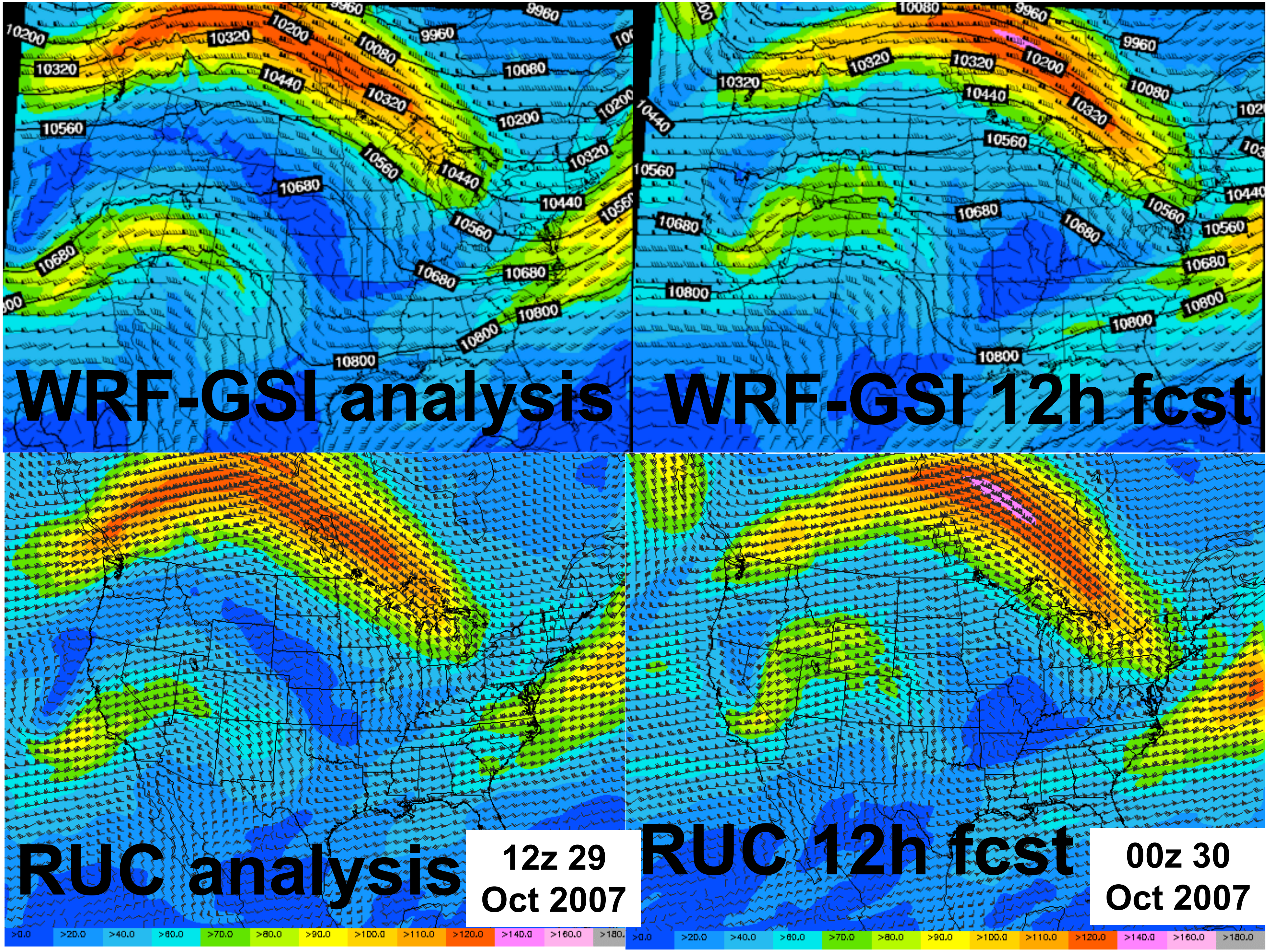
CONUS Rapid Refresh domain (3-h cycle)

RUC cycled
12-h forecast



GSI- WRF cycled
12-h forecast




WRF-GSI analysis
WRF-GSI 12h fcst
RUC analysis
12z 29 Oct 2007
RUC 12h fcst
00z 30 Oct 2007
>0.0
>20.0
>40.0
>60.0
>70.0
>80.0
>90.0
>100.0
>110.0
>120.0
>140.0
>160.0
>180.0

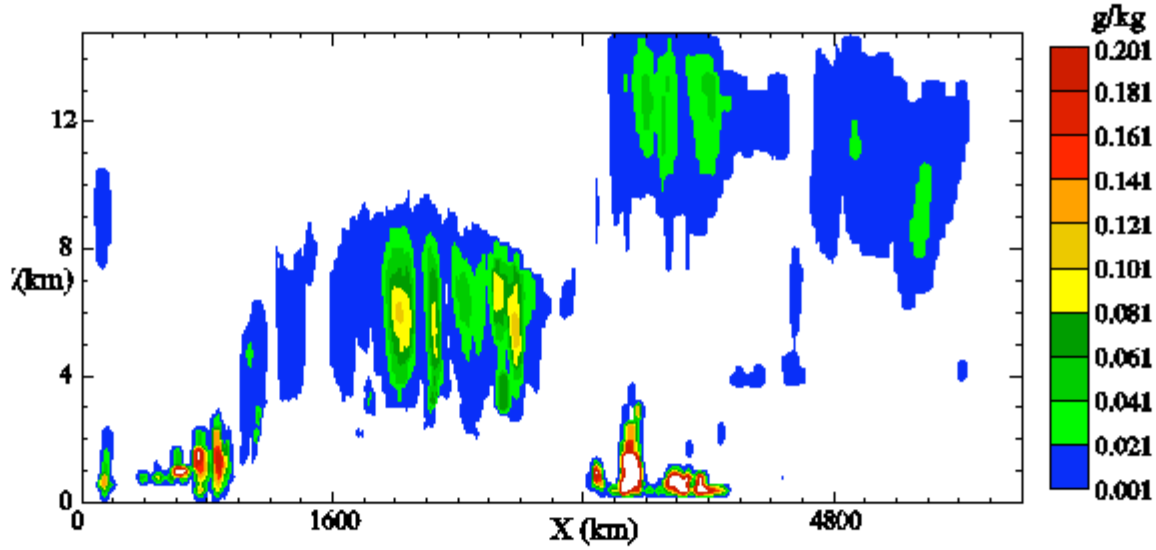
“RUC specific” components in GSI:

Cloud analysis (Ming Hu)

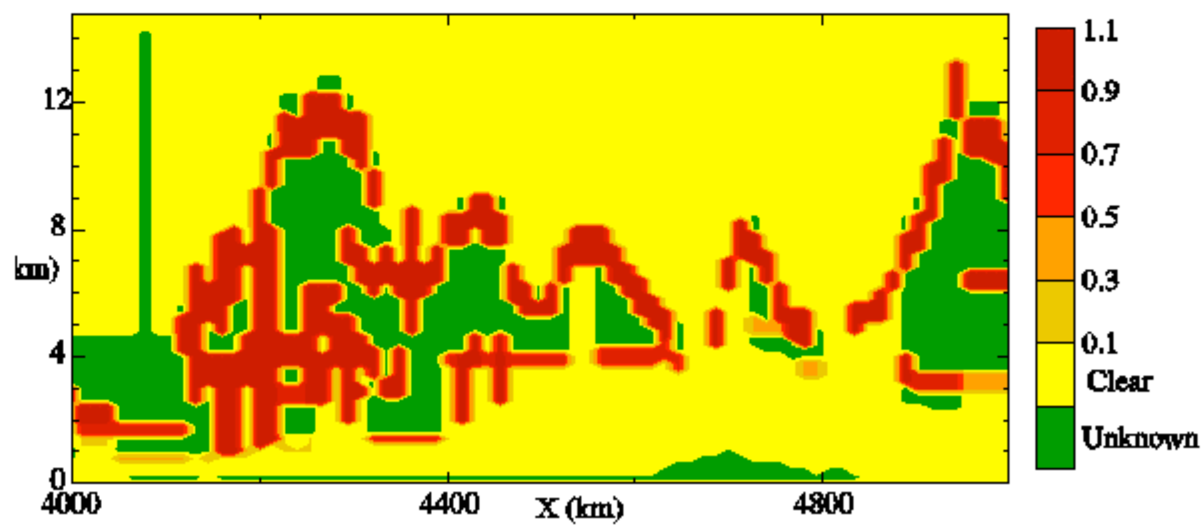
- Uses techniques from RUC, ARPS cloud analysis
- Utilizes METAR, satellite, radar data
- Modifies background cloud, hydrometeor fields
- Cycled testing within GSI framework
- Parallelized version for inclusion in full GSI

Updating cycled cloud / hydrometeor fields with METAR, satellite, radar observations

Background Cloud water + cloud ice



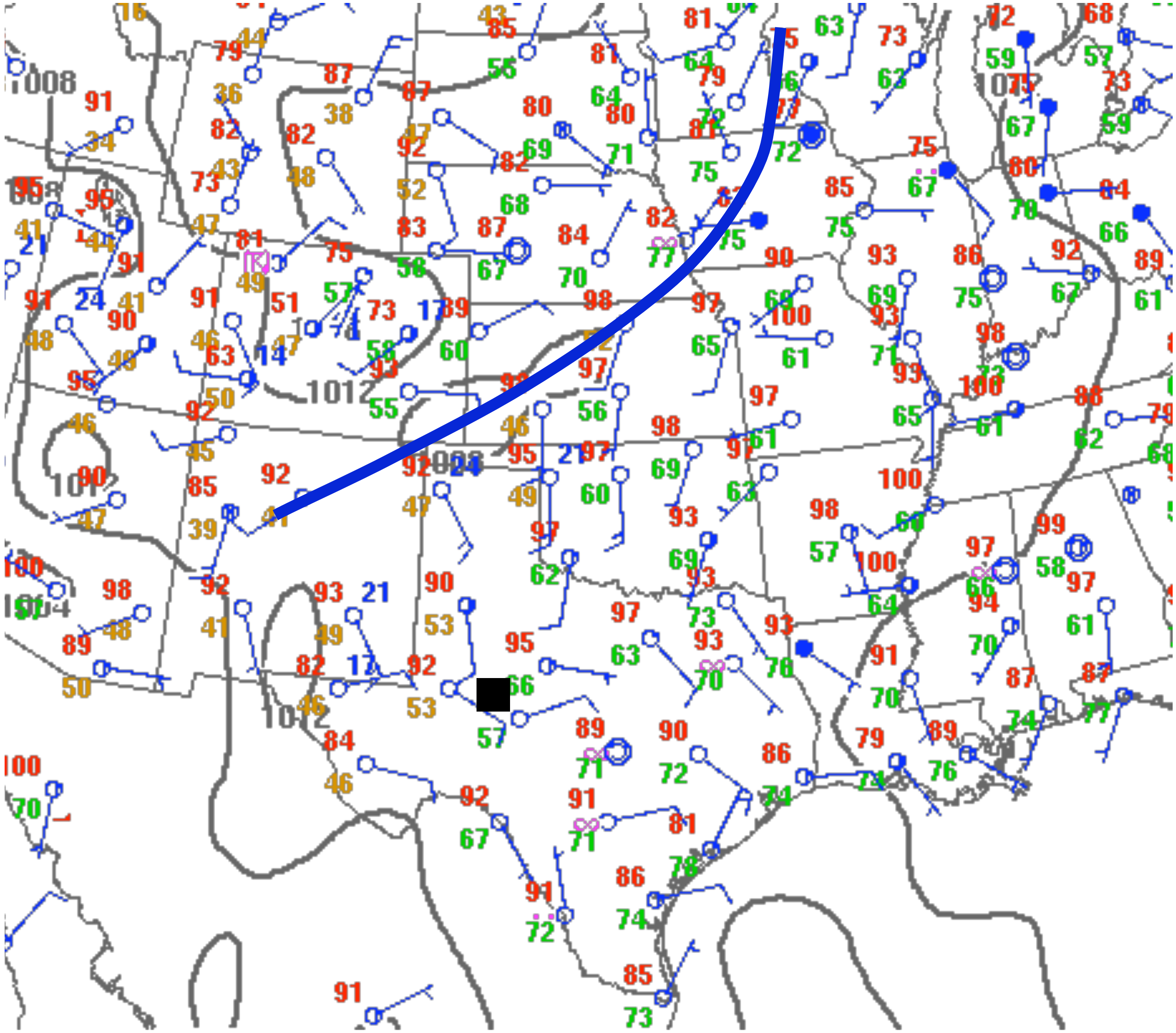
Cloud assessment (YES/NO/UNKNOWN) from observations (METAR/sat/radar)

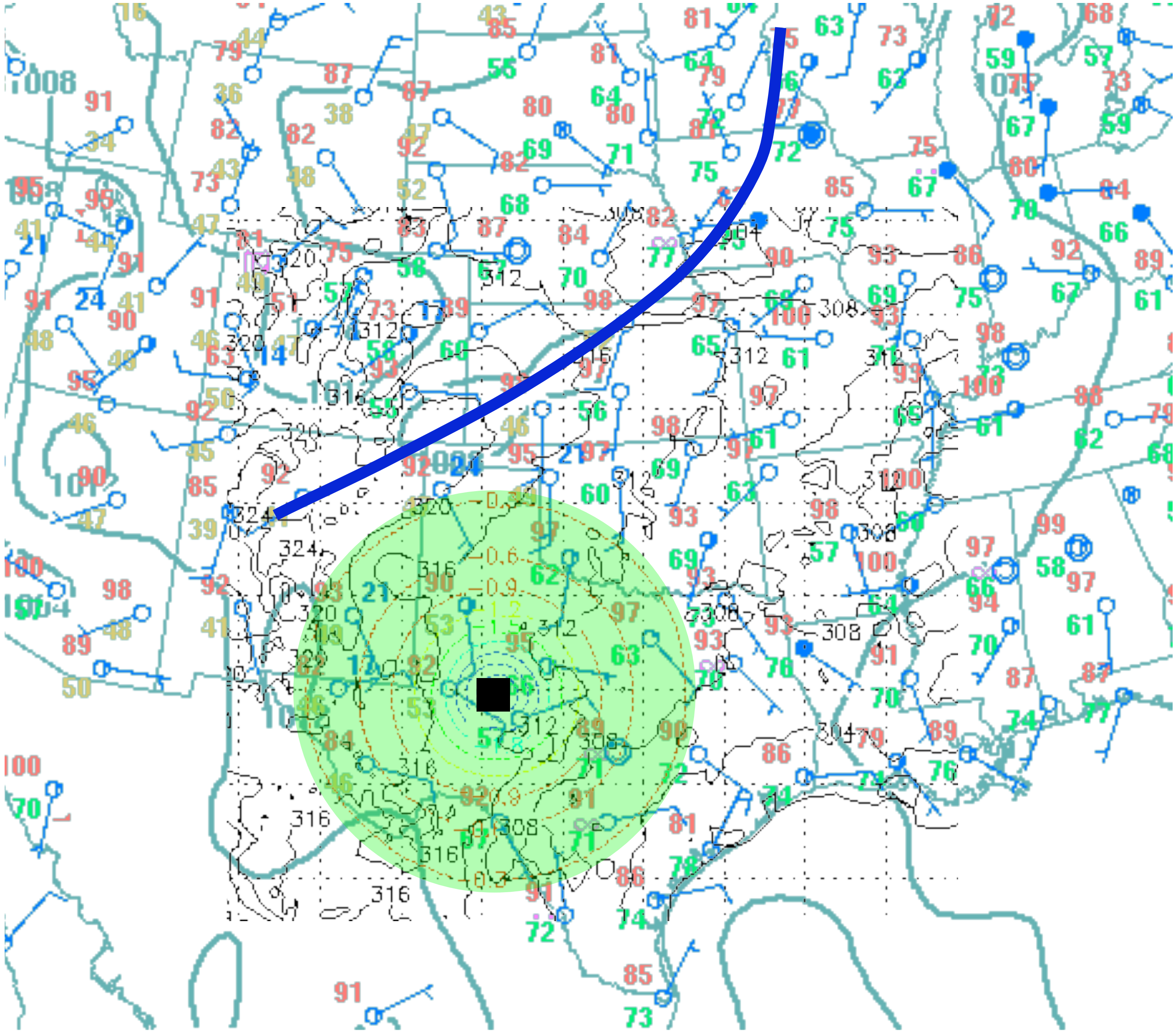


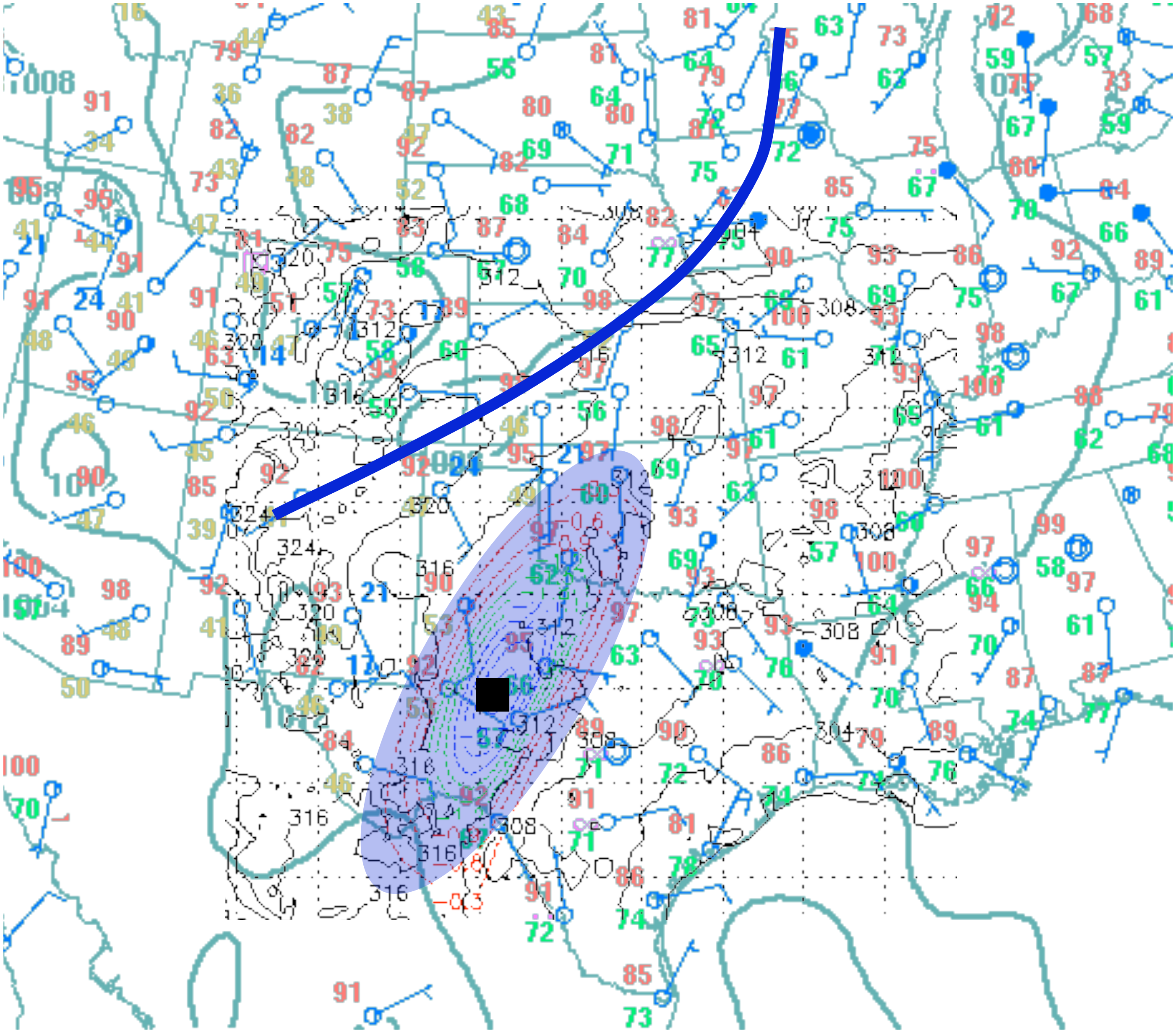
“RUC specific” components in GSI:

Anisotropic error covariance (Dezso Devenyi)

- Uses Jim Purser anisotropic recursive filters
- Collaboration with NCEP (Manuel Pondeca)
- Computationally feasible with coarser grid
- May improve horizontal observation influence
- Can use to vary vertical observation influence
- Use to do “PBL depth-based” surface observation assimilation







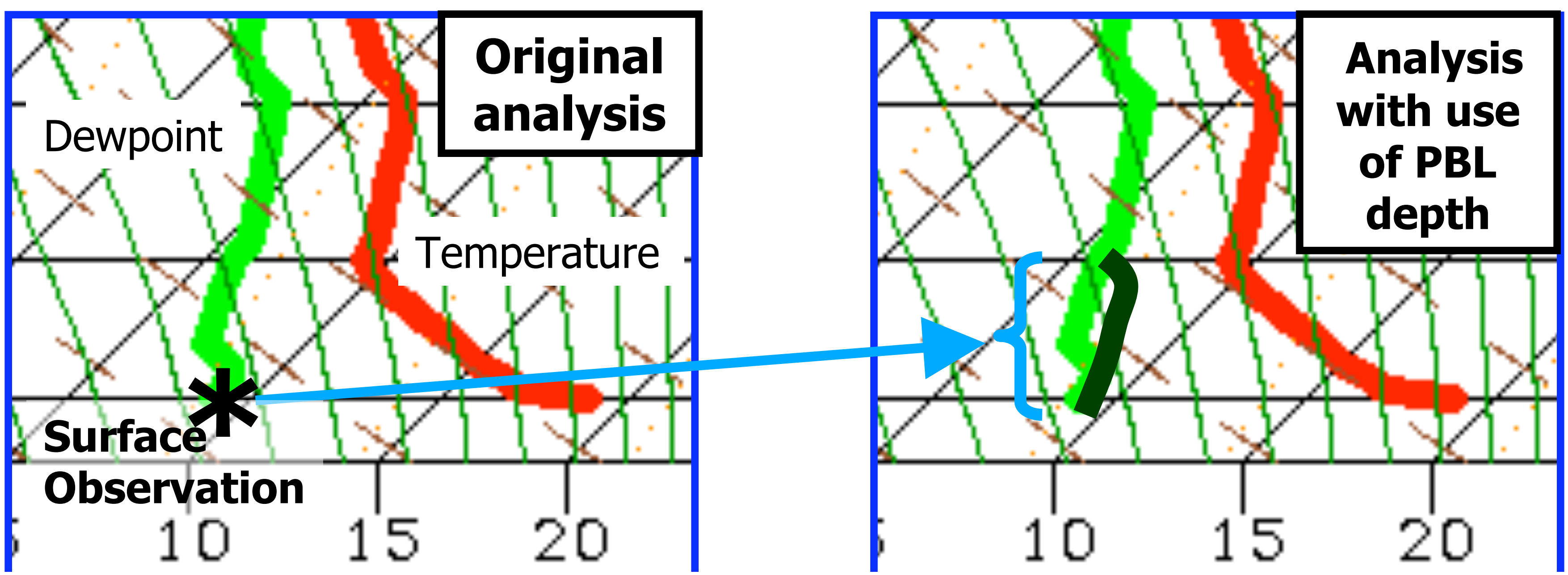
Use of surface information throughout boundary layer in the RUC & RR analysis

Problem

- Vertical influence of surface observations too small
- Surface information not retained in model forecast

Solution

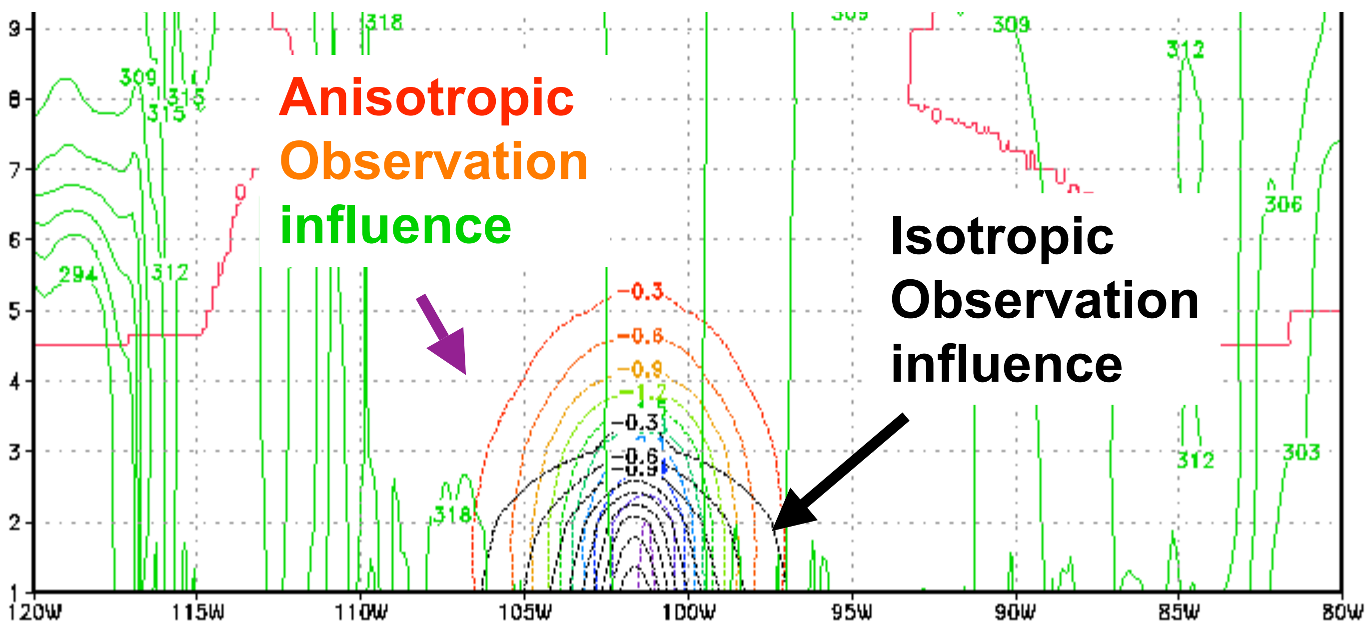
- Use METAR observation throughout PBL depth (from background field)
- Better model retention of surface observations



Varying vertical correlation length scale

- Can relate vertical length scale to potential temperature gradients

- Use to do “PBL depth-based” surface observation assimilation



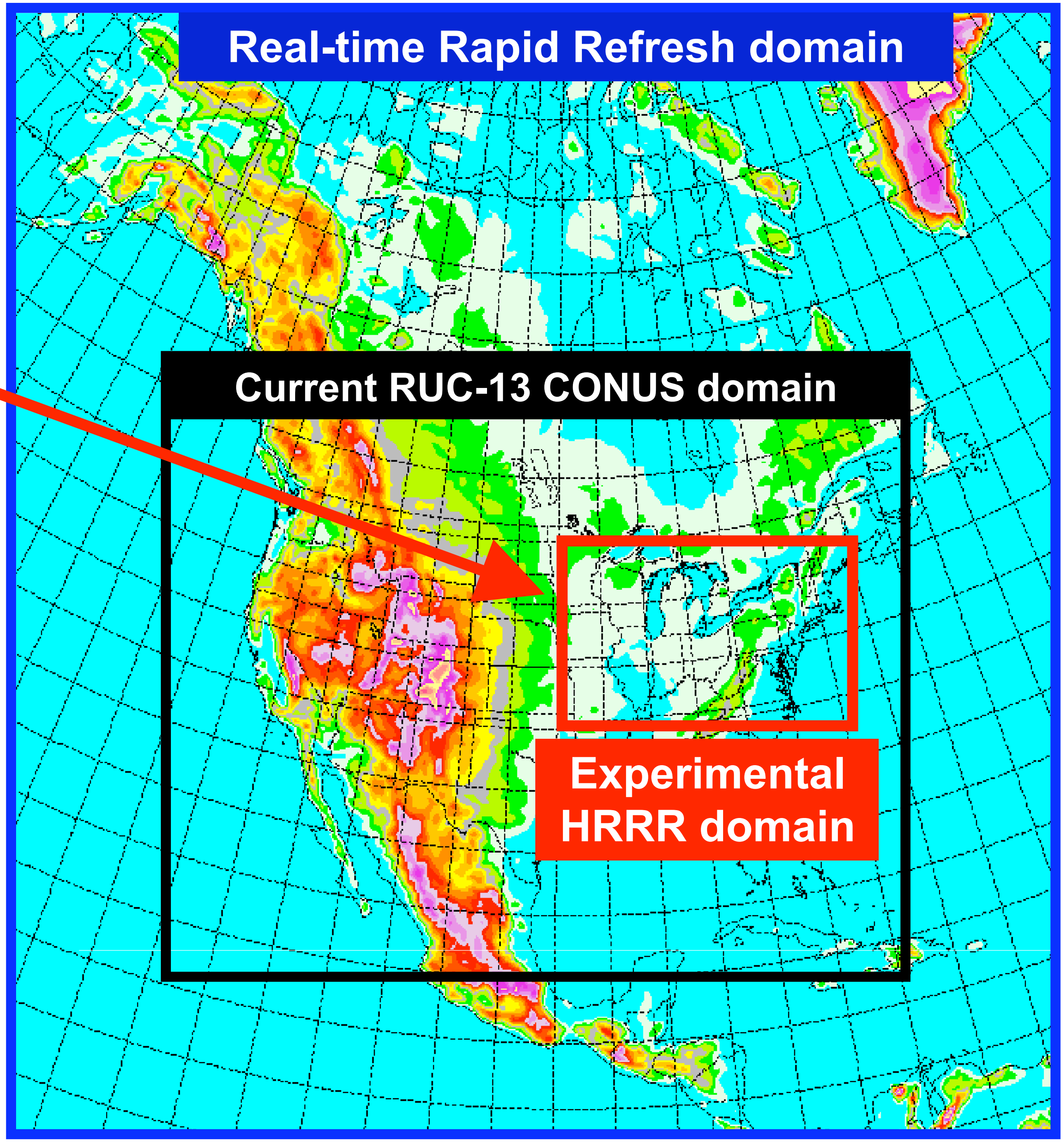
RUC, Rapid Refresh and HRRR domains

Experimental High-Resolution Rapid refresh

•Storm-resolving (3-km) model

• Initialize from RUC 13-km which uses diabatic DFI to assimilate radar reflectivity data

• Eventually update every 30-60 min using latest radar data, surface obs



Factors for Hourly Updating CoSPA NWP

- **10-13 km resolution (NAM, RUC, Rapid Refresh)**
  - **Good convective environment and parameterized storms**
  - **Good MCS prediction with radar enhanced RUC**
  - **Supported by NOAA/NCEP for operational reliability**
- **5-9 km resolution**
  - **Not recommended for convective applications**
    (convection parameterizations not appropriate
    and explicit convection does not behave properly)
- **1-4 km resolution**
  - **3-km recommended for initial CoSPA HRRR**
  - **3-km requires ~80x more computer resources than 13-km**
  - **3-km better than 4-5km in GSD and NCAR experiments**
  - **1-2km resolution may be better still but far more expensive**

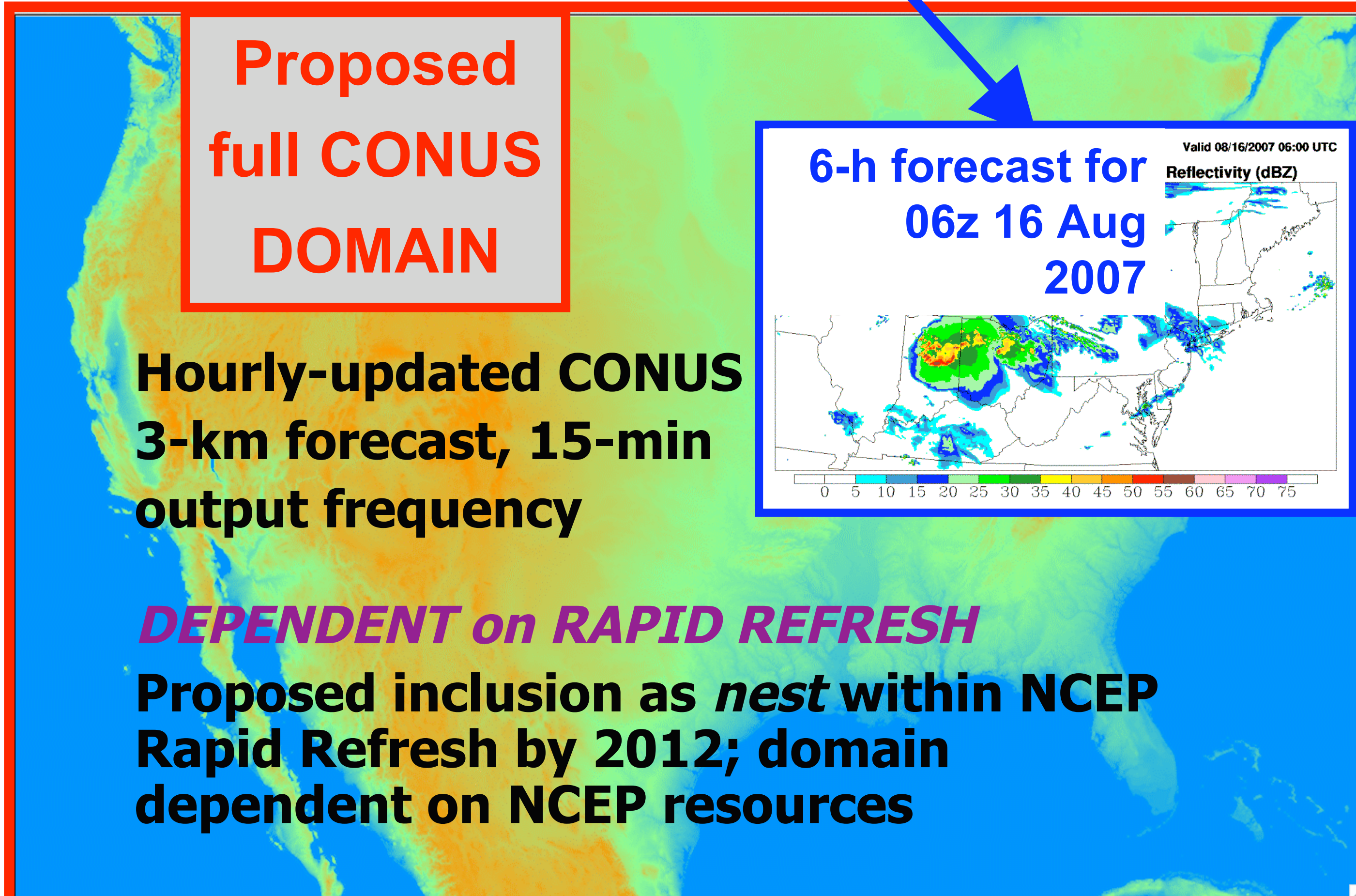
GSD High Resolution Rapid Refresh (HRRR) 3-km domain

Run Status:
Real-time at GSD, 12-h run every 3-h initialized from radar enhanced RUC - NE Corridor domain

Storm-scale fields for evaluation, time-lagged ensemble.

Collaboration:
AWRP partners, FAA, MIT/LL, NCAR, CAPS.

NE Corridor test domain - realtime forecasts started August 2007



Proposed full CONUS DOMAIN

6-h forecast for 06z 16 Aug 2007

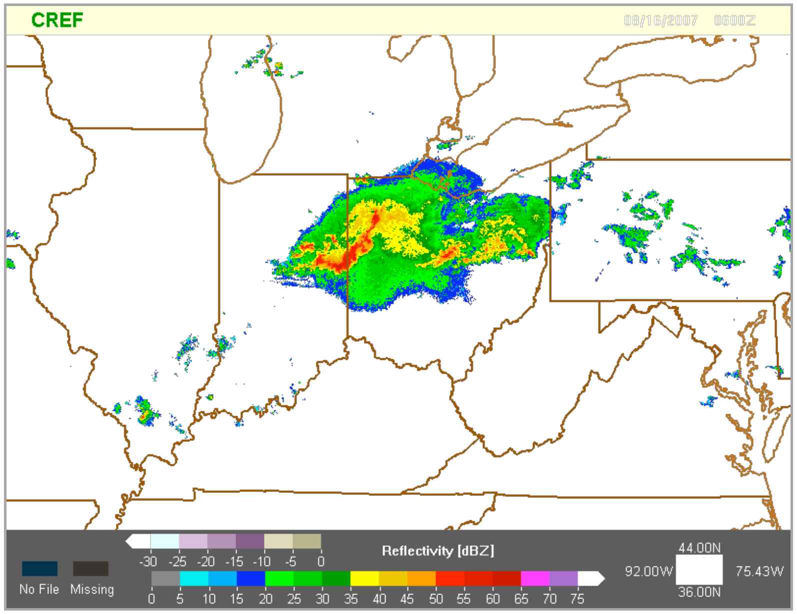
Hourly-updated CONUS 3-km forecast, 15-min output frequency

DEPENDENT on RAPID REFRESH

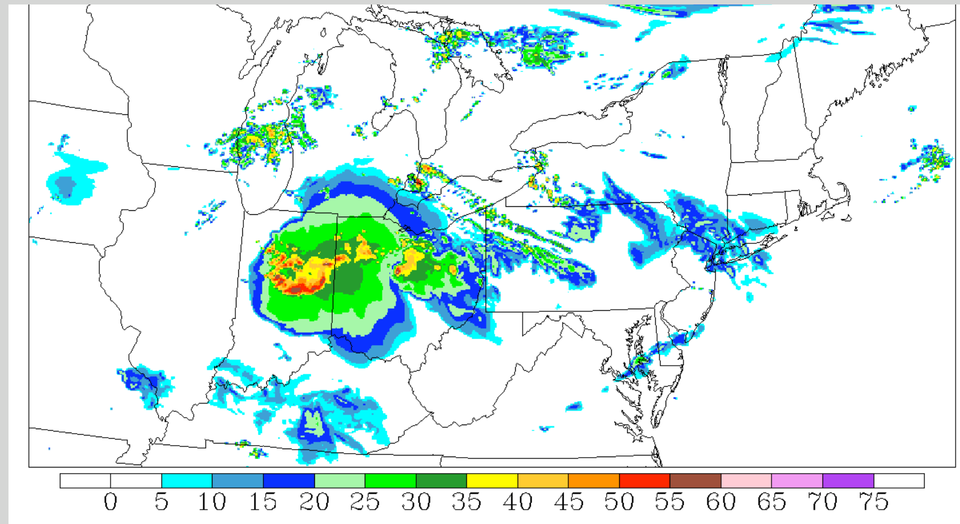
Proposed inclusion as *nest* within NCEP Rapid Refresh by 2012; domain dependent on NCEP resources

Sample HRRR from Radar-Enhanced RUC

NSSL verification



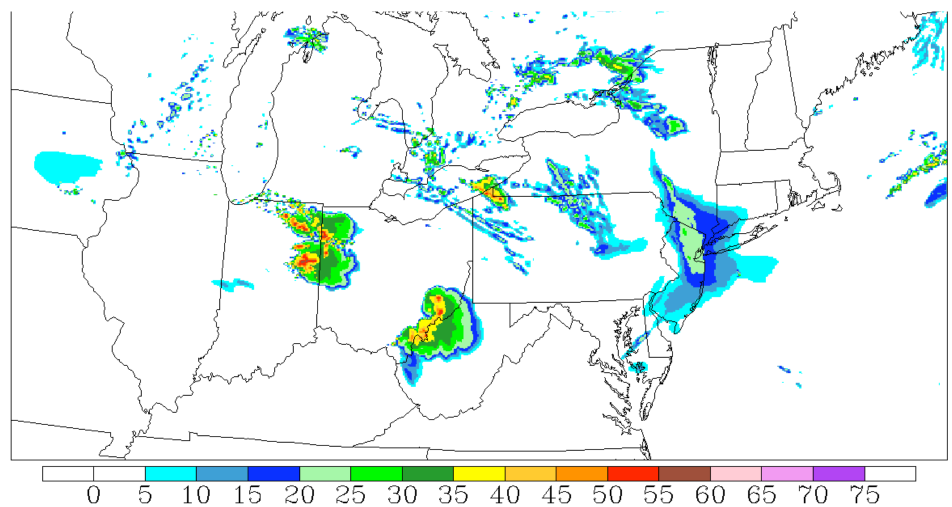
HRRR 3-km run initialized From radar-enhanced RUC

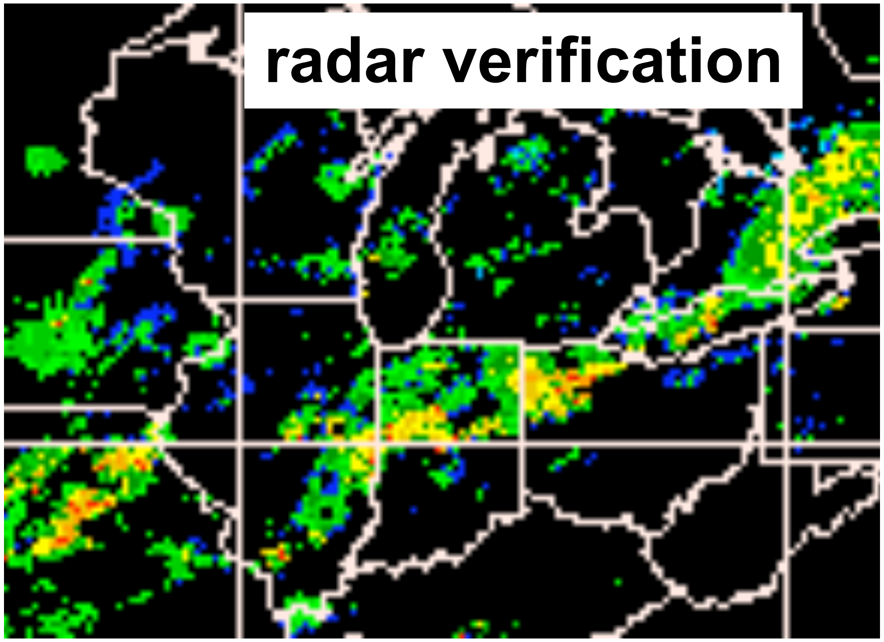


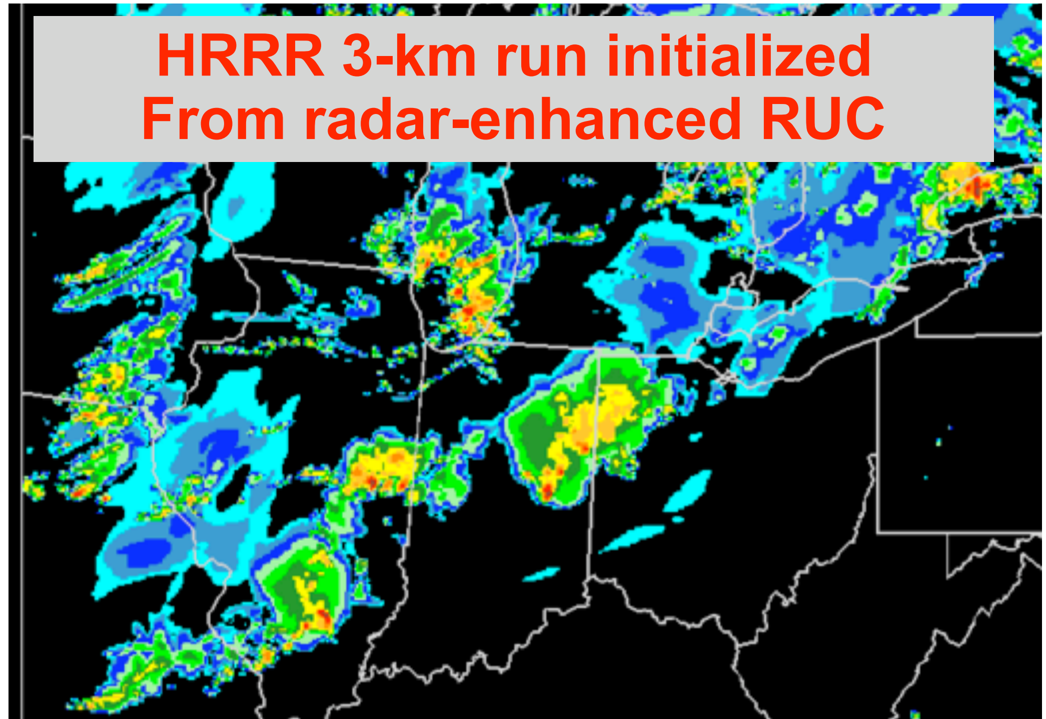
- **Much improved convection forecast from HRRR (*but* only if HRRR nested within radar-enhanced RR/RUC)**

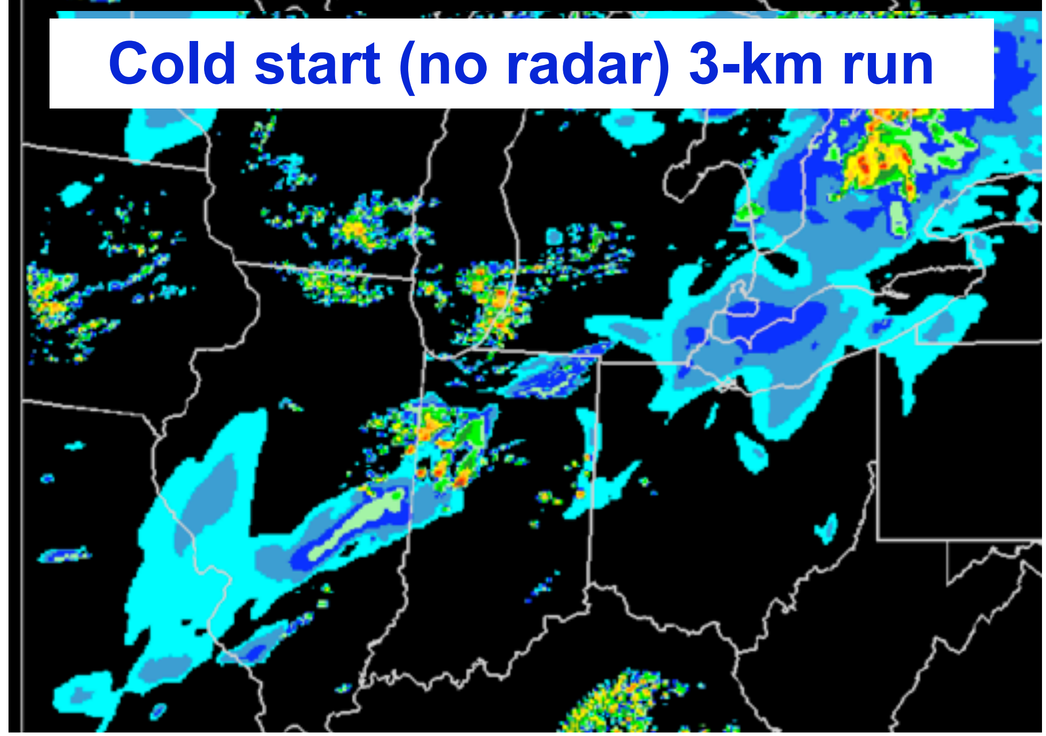
6-h forecasts valid 06z 16 Aug 2007

Cold start 3-km run









**HRRR from
rad RUC
and norad RUC**

**00z 25 AUG + 3h
fcst**

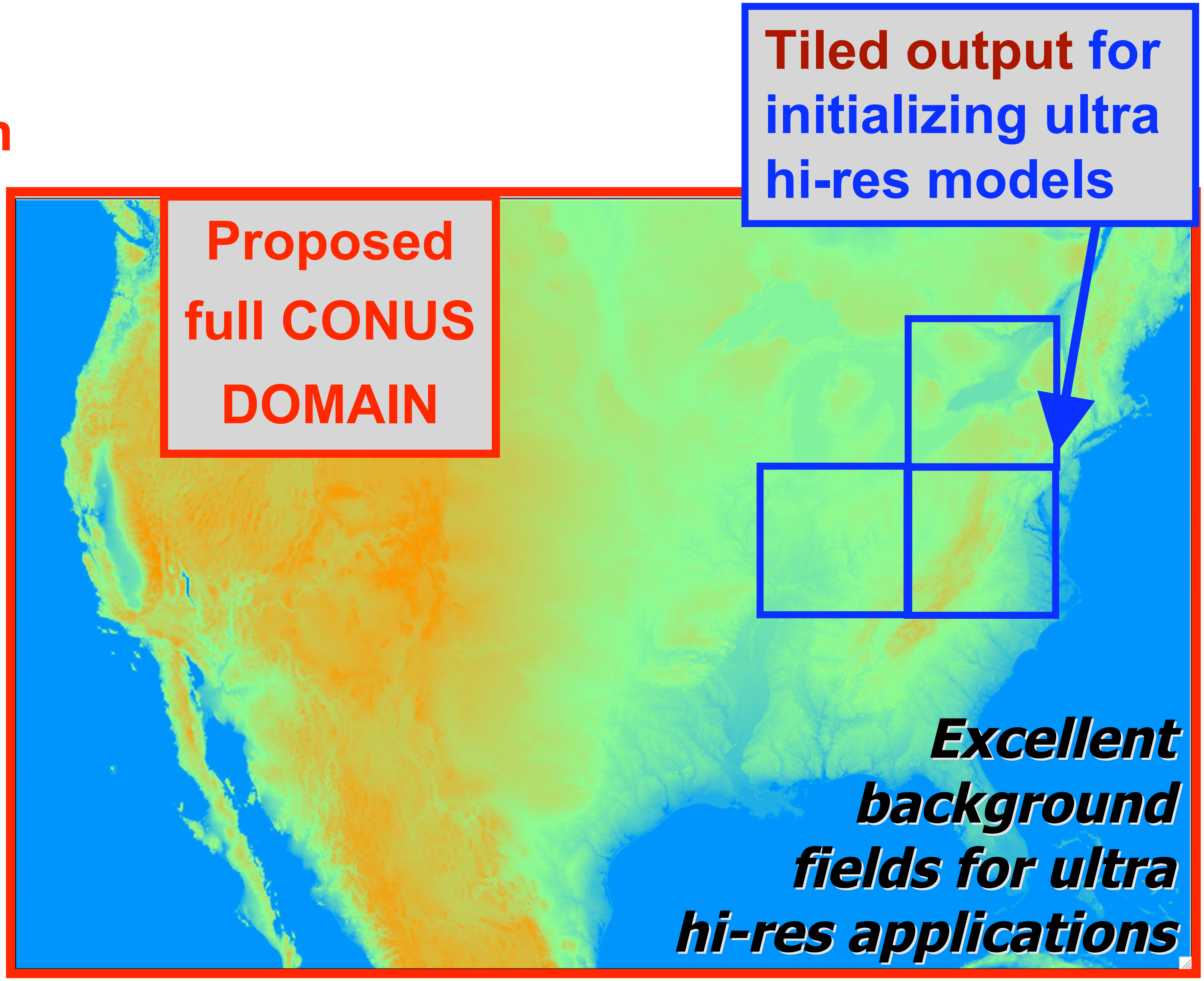
GSD High Resolution Rapid Refresh (HRRR) 3-km domain

Possible Ultra High Resolution applications:

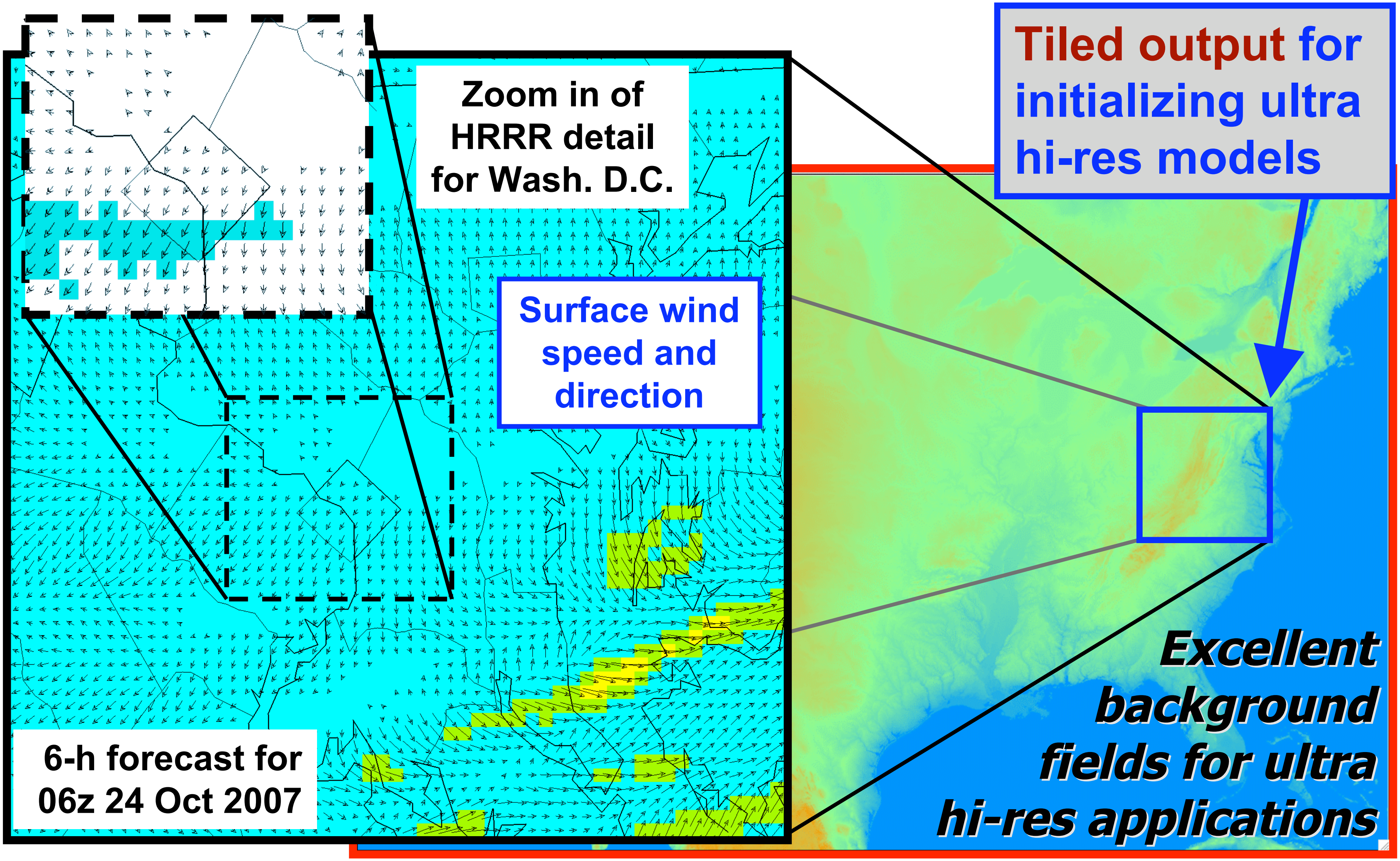
Sub-storm-scale severe t-storm / Tornado prediction (Warn on Forecast)

Wildland fire modeling

Urban pollution / hazardous release (using WRF-chem)



GSD High Resolution Rapid Refresh (HRRR) 3-km domain



RUC/Rapid Refresh Technical Review - OUTLINE

1:30 - 1:50	RUC upgrade - assim - radar reflectivity, mesonet/RTMA, physics - Stan Benjamin
1:50 - 2:15	Observation assessment activities - TAMDAR aircraft obs w/ moisture, larger obs sensitivity experiment (OSE) - Bill Moninger, Brian Jamison
2:15 - 2:25	Rapid Refresh background - core, NCEP - Stan
2:25 - 2:35	-- Break --
2:35 - 2:50	Rapid Refresh model description testing - ARW core, physics, DFI - John Brown
2:50 - 3:15	RR assimilation w/ GSI, Details on RUC/RR/HRRR convection Steve Weygandt
3:15 - 3:25	Future of Rapid Refresh Stan Benjamin

Future of Rapid Refresh

- **Fall 2007 – Spring 2008**

  - Real-time and retrospective cycled RR testing

  - Testing of diabatic DFI with radar data assimilation

- **Summer-fall 2008**

  - Transfer Rapid Refresh code to NCEP, testing begins there

  - Testing continues at GSD

- **Fall 2009**

  - NCEP implementation of Rapid Refresh to replace RUC

- **2012**

  - NCEP implementation of Rapid Refresh ensemble with

  - 3 ARW members and 3 NMM members

  - using ESMF framework (Earth System Modeling Framework - NOAA, NASA, DOD, NCAR consortium)

RUC/RR project sponsors

- FAA Aviation Weather Research Program
  - Model Development and Enhancement Research Team
  - Convective Weather Research Team
- NOAA/ESRL/GSD
- FAA TAMDAR project

RUC colleagues (outside ESRL)

- NCEP – Geoff Manikin, Geoff DiMego, EMC, NCO…
- FAA Aviation Weather Research Program
  - Ken Leonard, Gloria Kulesa, Warren Fellner…
- NCAR
  -Roy Rasmussen, Greg Thompson, Jenny Sun, Jordan Powers, …
- WRF community
- DTC (NCAR and GSD colleagues)
- Aviation Weather Center
  - Fred Johnson, Clinton Wallace, Steve Silberberg
- Storm Prediction Center
  - Steve Weiss, Jack Kain, Phillip Bothwell…

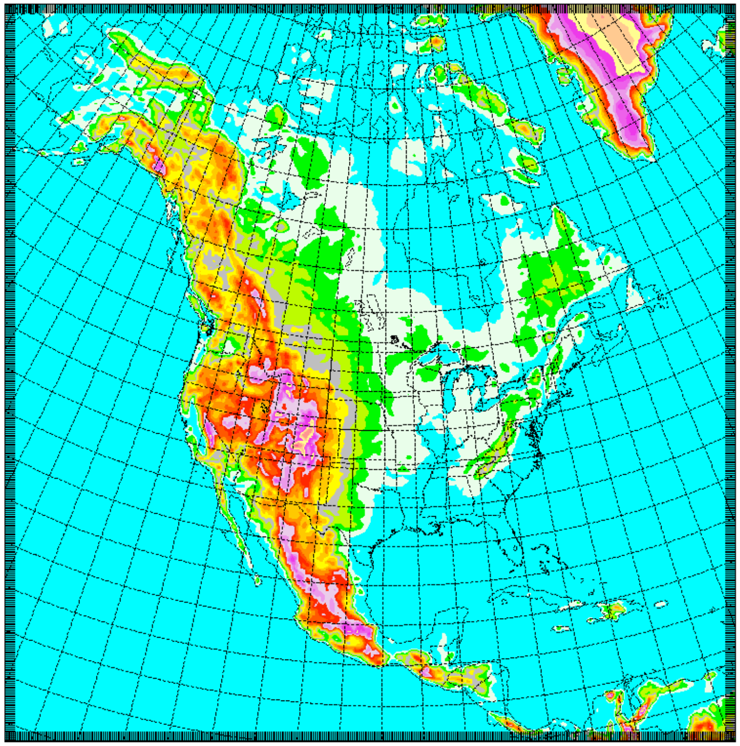
- NWS Regions, individual WFOs
- NESDIS/CIMSS – Madison, WI – Bob Aune, Paul Menzel
- NWS – Kevin Johnston, Dave Helms….

Rapid Refresh – 2009+

- International use throughout North America
→ ultimately, global

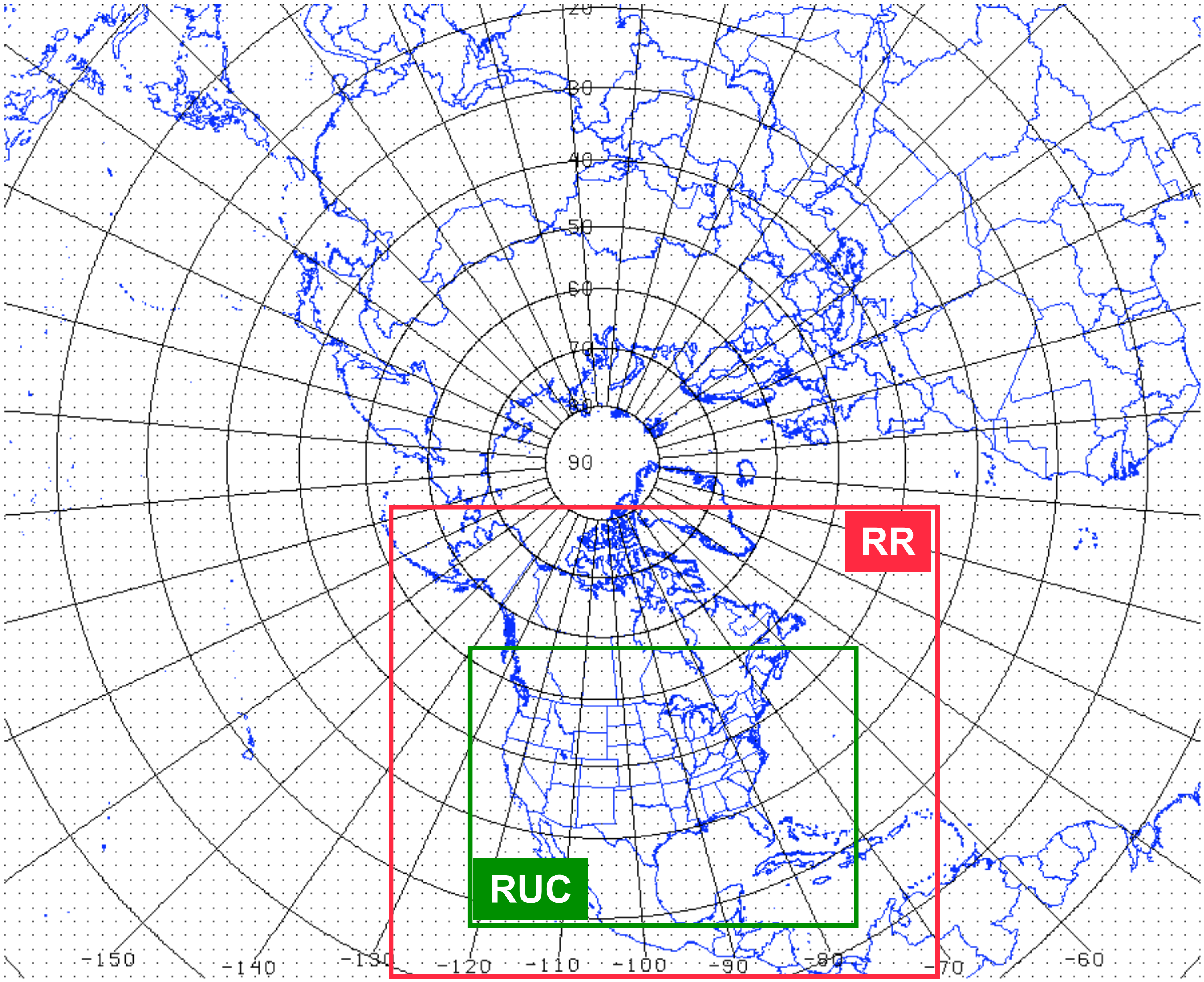
- Assimilation of
    - radar reflectivity, radial winds
    - GOES /POES satellite radiances
    - satellite cloud drift winds
    - scatterometer winds
    - All RUC-assimilated observations

- 'Situational awareness fcst model'
- 3-km High-Resolution Rapid Refresh (HRRR)
- Chem-Rapid Refresh
    - improved clouds, visibility



Trends for our perspective

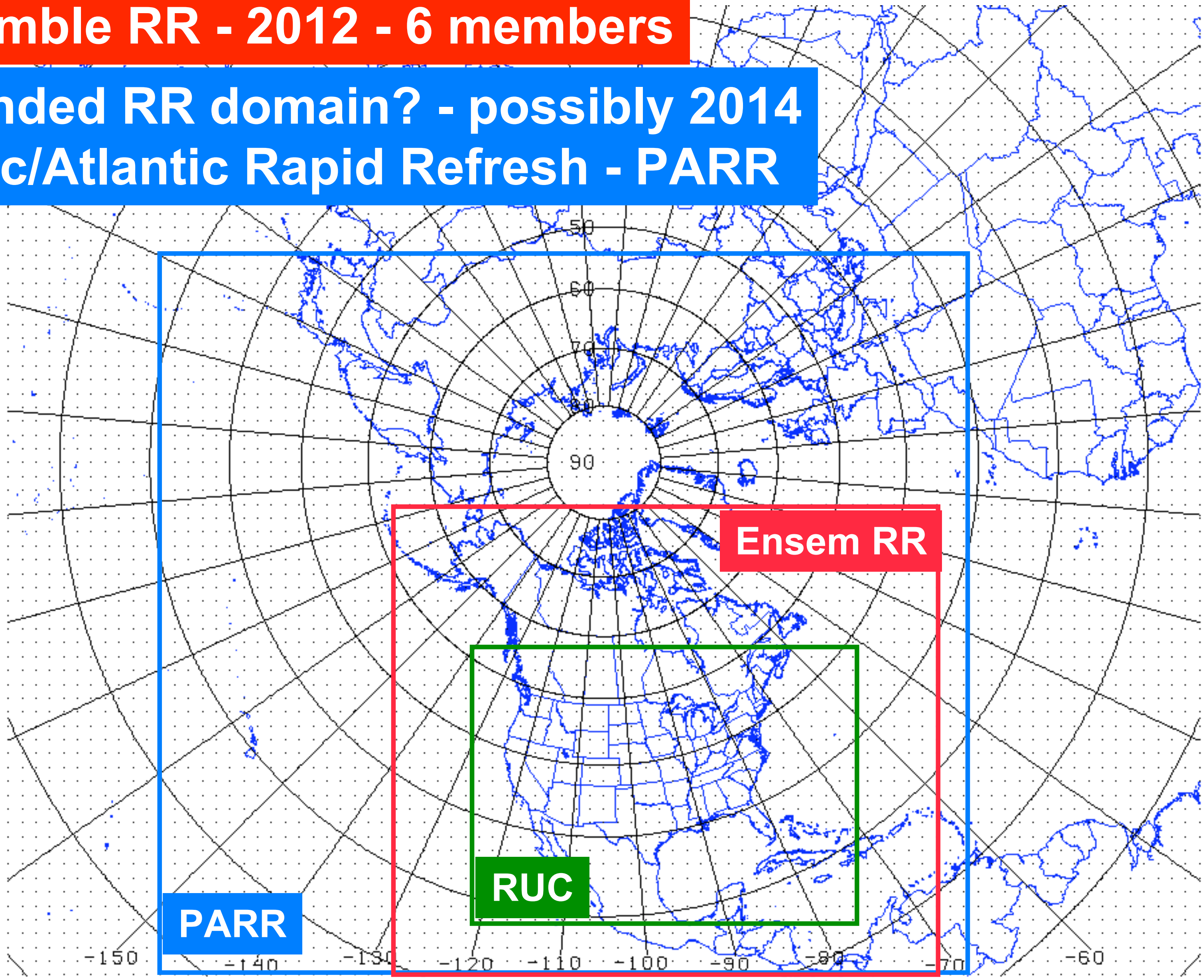
- Use of high-frequency NWP data continues to grow with increasing automation of decision-making, access to gridded data
- More interaction with intermediary developers of post-processing products, esp. probabilistic products
- Common development/implementation with NOAA – ESMF beyond WRF
- Ensemble Rapid Refresh
- Common computing system in NOAA
- Increasingly coupled environmental systems



NCEP Grid 55

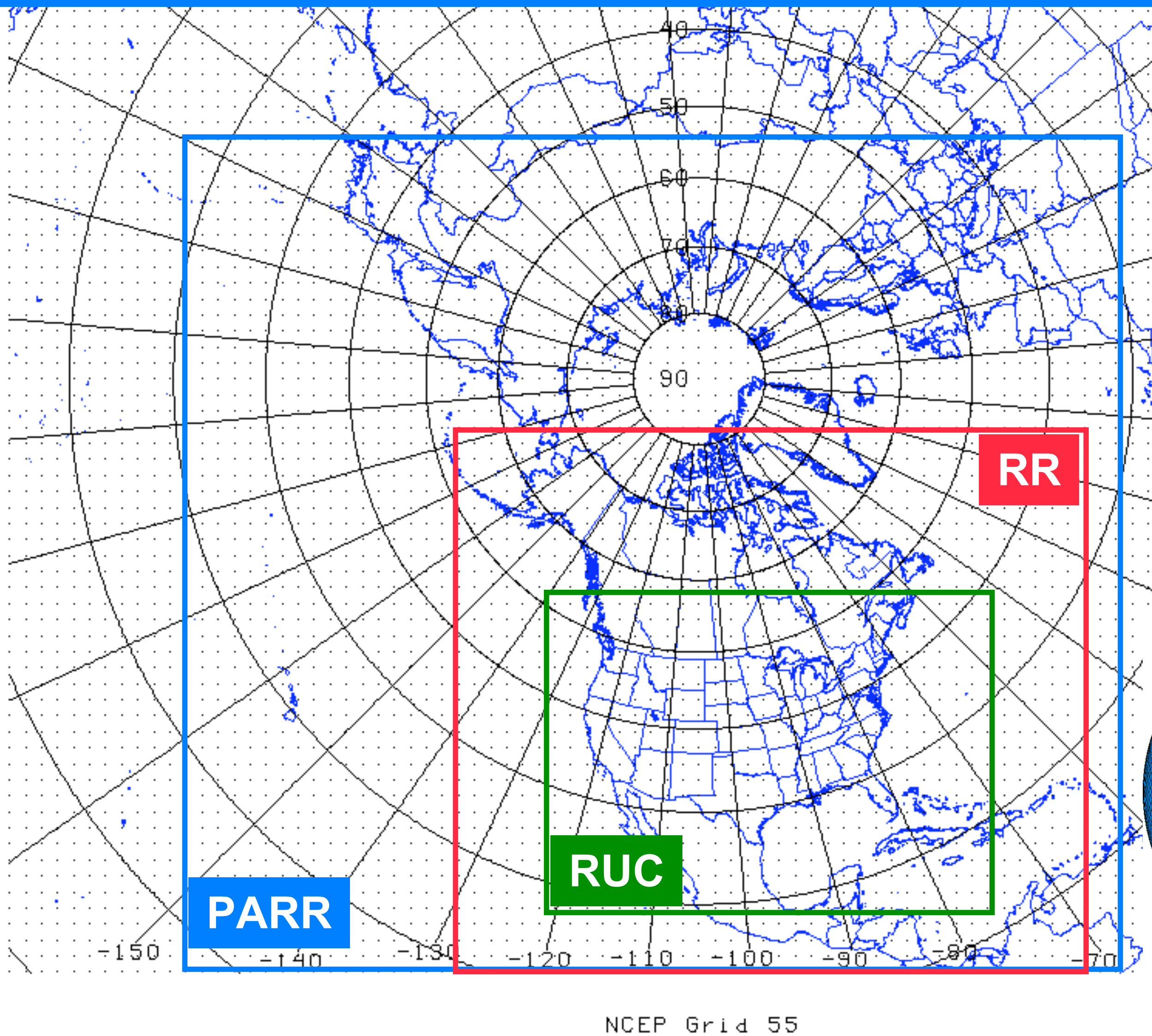
Ensemble RR - 2012 - 6 members

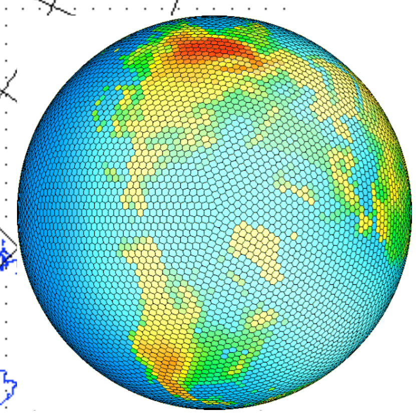
Expanded RR domain? - possibly 2014
Pacific/Atlantic Rapid Refresh - PARR



NCEP Grid 55

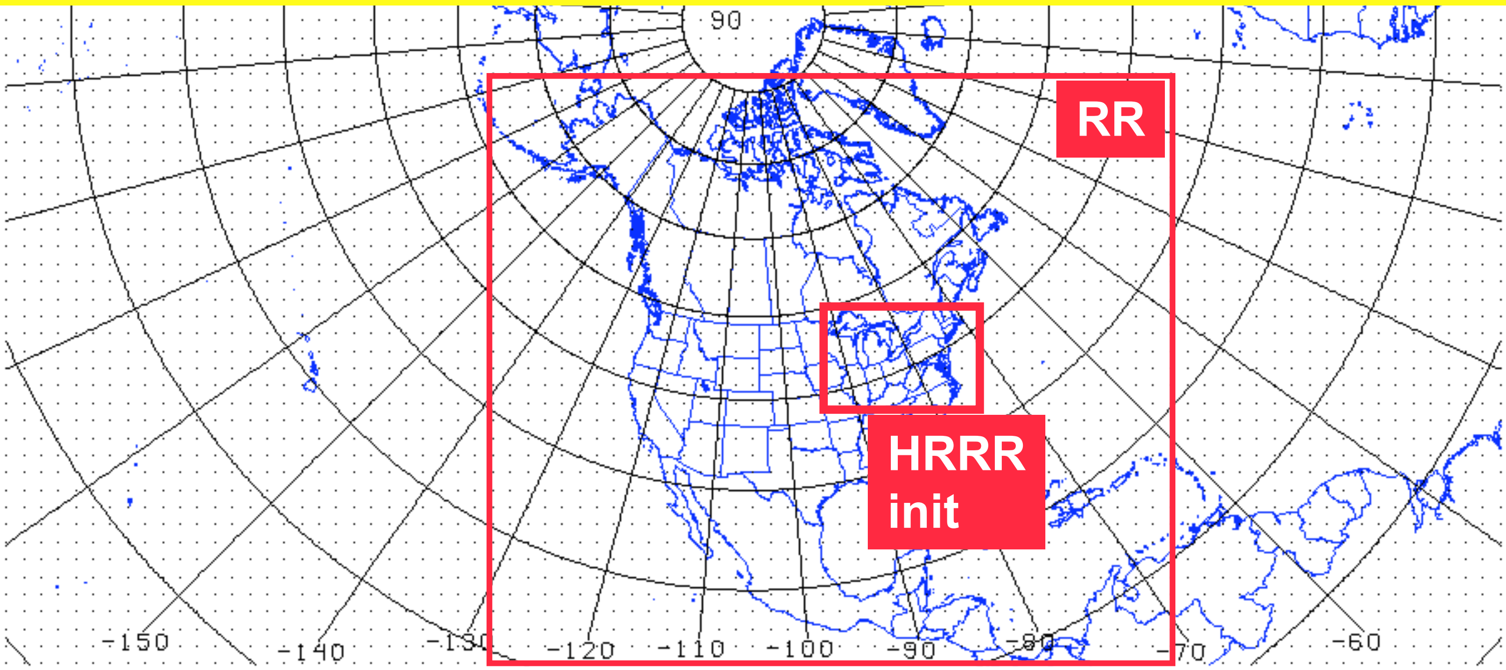
Global Rapid Refresh - hourly updated - 2016
New global satellite ground stations - 40min availability





Transition to operations for HRRR

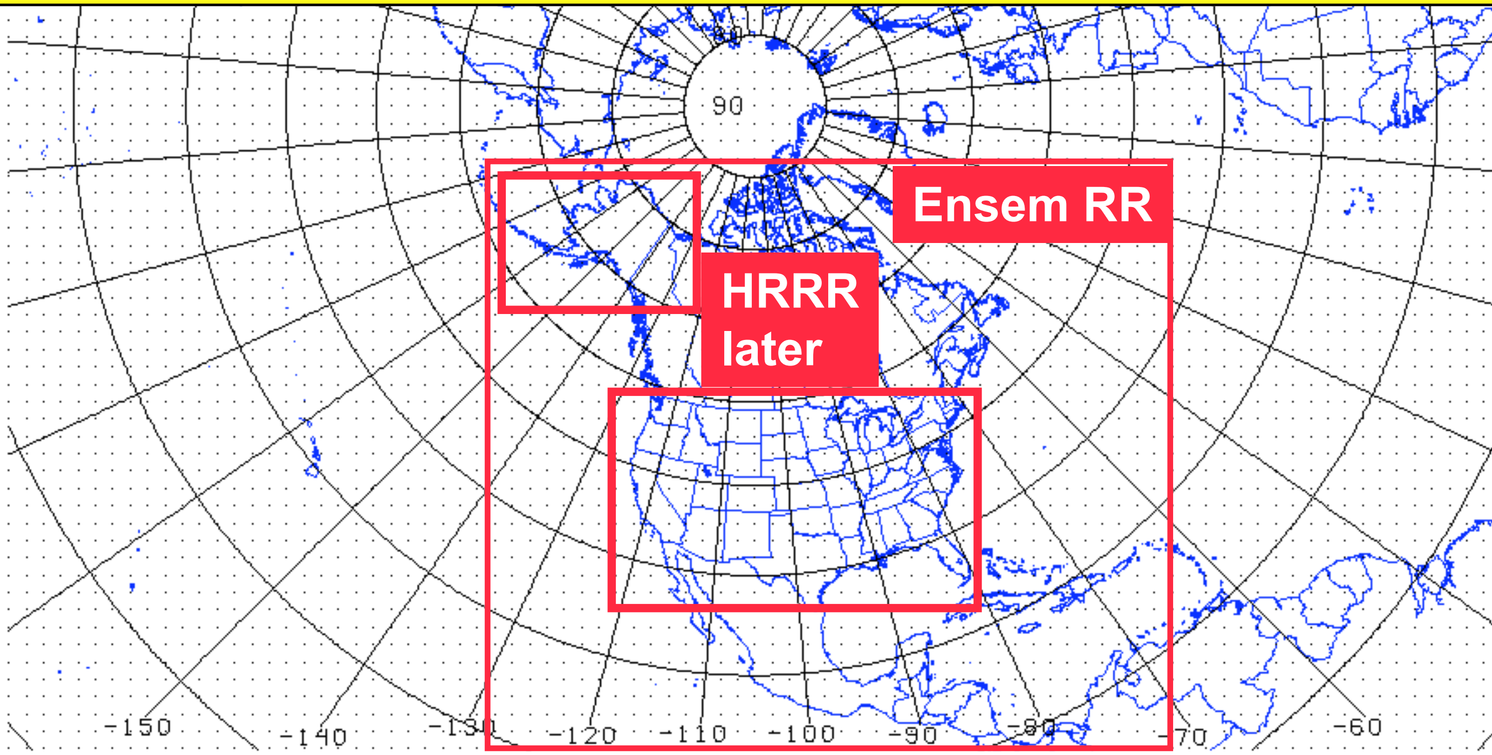
- Proposed *nest* within Rapid Refresh running at NCEP
- Domain size dependent on computer resources
- NE Corridor HRRR nest inside RR proposed for 2012
- GSD HRRR will provide experimental/demo products until NCEP implementation



NCEP Grid 55

NextGen - (Next-Generation Air Transportation System) will be a key driving factor

- **Full continuity between hourly Rapid Refresh and HRRR is essential**
- **As computer resources become available, HRRR build-out will include CONUS and Alaska nests**



NCEP Grid 55

Very **Short-Range Ensemble Forecasts - VSREF**
- Updated hourly

RR – time-lagged ensemble members
- 2012 - ensemble RR

NAM / NAM ensemble

GFS / GFS ensemble

SREF (updated every 6-12h)

MOS/LAMP, statistical correction

VSREF to include
- merged RCPF/extrap
- similar for icing, turb, etc.

VSREF –
Hourly
Updated
Probabilistic
Forecasts

Rapid Refresh Development and Testing

Major transitions:

- Rapid Refresh planned for FY09
  - WRF ARW, GSI, North America
- Ensemble Rapid Refresh
  - proposed by 2012, to use ESMF framework
- High-Res Rapid Refresh (HRRR) – proposed to NCEP by 2012
  - 3km hourly updated 12h forecast
  - In testing at GSD
  - Covering NE Corridor

http://rapidrefresh.noaa.gov